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# ERADICATION OF POISON IVY (*RHUS RADICANS* L.)

## I. EXPERIMENTS WITH SODIUM CHLORATE, SODIUM CHLORIDE, AND TWO PETROLEUM OILS[1]

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Every summer dermatitis, caused by poison ivy, is responsible for considerable discomfort and, in some cases, loss of time. In spite of the ever existing danger of poisoning, however, there has been no organized effort at eradication. From the limited literature giving experimental results, there would appear to be a paucity of published data on the eradication of poison ivy with herbicides.

Hansen (9) reported the destruction of poison ivy with thorough applications of sodium chlorate. Pieper and Hackleman (18) concluded from two years' results that poison ivy could be eliminated from orchards by the use of chlorates or ammonium thiocyanate but complete eradication was apparently not obtained in the experiments reported. Beach (2) investigated the effect of 5 rates of application of sodium chlorate to poison ivy growing beneath apple trees. He found that single applications of 3 pounds per square rod gave an excellent kill of poison ivy. Heavier applications injured the trees. In the papers of Howitt and Gammon (11, 12, 13) and of Willard (22), general results or recommendations based on results are given for the application of chlorates to poison ivy but no experimental details are included. A large number of publications including Adams (1), Crooks and Kephart (3), Eseltine (4), Fiske (5, 6), Grant and Hansen (7), Groh (8), Harlow (10), Kephart (14), Maguire (15), Muenscher (16), Robbins, Crafts and Raynor (19), Steinbauer and Steinmetz (20), and Stoddard (21) give recommendations for the eradication of poison ivy but whether or not these are based on experimental results is not stated.

To obtain information on the eradication of poison ivy, under conditions prevailing at Ottawa, Canada, the experiments herein reported were undertaken in 1935. Although not elaborate in design, close observations were made throughout the duration of the experiments, and for several years following the final application. All treatments were carried out on small plots, with simple equipment, (Plate I, Figure 1), and under conditions easily duplicated by owners of small properties.

### EXPERIMENTAL METHODS

The herbicides investigated were sodium chlorate, sodium chloride (common salt), and the petroleum oils, furnace fuel oil, and a water white kerosene with the trade name of longtime burning oil. Three types of

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applications were made: spray, sprinkle, and dry salt. For the spray treatments a knapsack sprayer of 3-gallon capacity was used. For the sprinkle experiments applications were made with a sprinkling can of $1\frac{3}{4}$-gallon capacity supplied with a rose 3 inches in diameter with 41 perforations each approximately $\frac{1}{16}$ of an inch in diameter. In dry salt applications the material was broadcast by hand over the plot. If the amount of herbicide to be applied was less than 5 pounds it was thoroughly mixed with sufficient dry sand to bring the total to this amount. In the majority of the experiments the applications were made in the late afternoon.

All experimental plots were in the vicinity of Ottawa West, Ontario, on very shallow Farmington loam over limestone bedrock. Stones were numerous on the surface of many of the plots.

Estimates of the percentage cover of poison ivy were made visually before and after each application. They were made throughout by the same operator and represent ground cover, that is, the percentage of the area of the plot covered with poison ivy foliage. They do not take into account the density of the foliage in those areas covered with poison ivy.

## RESULTS

A résumé of experimental details and the results obtained will be found in Table 1.

### Sodium Chloride

*Spray.* (Table 1. Exp. 8, Plot 4.)

A total of 14 applications, each of 3 pounds of salt dissolved in 1 gallon of water, applied over a 5-year period to a plot of 1 square rod in area, reduced the poison ivy cover from 85% to 13%. The checking of growth was of temporary duration however, since by the second year after the last treatment the ivy had recovered to 60%.

*Sprinkle.* (Table 1. Exp. 8, Plot 7.)

A similar number of applications over the same period but consisting of 6 pounds salt in 2 gallons water and made with a sprinkling can reduced the poison ivy from 85% to 3%. The control was more permanent here as the stand had only increased to 10% of ground cover in the second summer after the last treatment.

With both the spray and sprinkle applications of common salt, each treatment killed the majority of the ivy leaves, provided the weather remained dry. New leaves were soon produced, however, and the next treatment could be made 5 to 6 weeks later. Some of the treatments were washed off by rain and thus did not affect the ivy foliage. The better control obtained with the sprinkling can no doubt can be explained by the effect of the large amount of salt on the underground rootstocks. In the later treatments, when the stand had been thinned out considerably, the major part of the 2 gallons was applied to those plants still present. Thus the 84 pounds, the total for all applications, was not applied evenly to the plot as a whole but was concentrated around the underground stems and no doubt acted as a sterilizing agent.

*Dry Salt.* (Table 1. Exp. 10, Plots 12–15, and Exp. 11, Plots 1–5.)

Applications of common salt broadcast by hand on October 7, 1936, even when as heavy as 100 pounds per square rod, had no effect on poison ivy. In the summer following the applications, there was no noticeable difference between the untreated check areas and those treated with common salt.

Weather data provided by the Field Husbandry Division, Central Experimental Farm, Ottawa, characterize 1936 as a very wet open fall. During October, rain fell on 16 days for a total precipitation of 5.14 inches (0.27 inches fell as snow) as compared with the 50-year average precipitation of 2.59 inches (0.04 falling as snow). All the snow that fell during October and November melted on the ground and as late as December 16 the fields were three-quarters bare. As a result, no salt was visible above ground on any of the plots 14 days after the applications were made. The salt was no doubt leached from the soil before affecting the poison ivy.

Applications made in June gave somewhat better results in that 40 pounds common salt reduced the poison ivy in a square rod plot from 70% to 20%, and 60 pounds reduced the ivy cover from 50% to 15%. Neither 10 nor 20 pound applications on similar areas had any effect.

## Petroleum Oils

*Sprinkle.* (Table 1. Exp. 8, Plot 6.) Eleven applications, each (except the final one) consisting of 2 gallons furnace fuel oil applied with a sprinkling can to 1 square rod of poison ivy, over a 5-year period, reduced the poison ivy cover from 85% to 3%. Each application killed all the leaves present regardless of whether it rained afterward or not. However, new leaves soon appeared. The reduction in stand was gradual over the 5-year period and the plants were quite small during the latter part. The grass was killed by the first application so the only plants present during remainder of treatment, other than poison ivy, were such coarse weeds as *Melilotus alba* Desr., *Lactuca scariola* L., *Linaria vulgaris* Hill, *Hypericum perforatum* L., etc. As a result, the plot was unsightly.

*Spray.* (Table 1, Exps. 13 and 14.)

Applications of a water white kerosene, made with a knapsack sprayer at the rate of 2 gallons per square rod, in the month of June, had very little effect on the poison ivy present whether applied to the upper or under surface of the leaves. A few of the young ivy leaves developed brown curled edges following the applications but the majority of leaves remained normal in appearance. There was a tendency for some of the ivy leaves to develop a yellowish or reddish colour resembling autumn coloration, in the second or third week after treatment.

## Sodium Chlorate

*Mode of Application: Spray, Sprinkle and Dry Salt.* (Table 1. Exp. 8, Plots 1–3.)

Two pounds of sodium chlorate were applied to each of 3 plots, 1 square rod in area. The applications were made in the month of June for 2 successive years. The treatments, consisting of (1) a spray of 20% solution,

TABLE 1.—EXPERIMENTAL DETAILS AND RESULTS OBTAINED WITH APPLICATIONS OF SODIUM CHLORATE, SODIUM CHLORIDE, AND PETROLEUM OILS TO POISON IVY

| Exp. no. | Plot no. | Plot size | Herbicide | Applications | | | | | | | | | | | | Total amt. herbicides used | Poison ivy cover (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Mode | When made | Amt. applied in first application | No. per year | | | | | | | No. yrs. made | | Total no. | | | Before treatment | After treatment | | |
| | | | | | | | 1st year | 2nd year | 3rd year | 4th year | 5th year | 6th year | 7th year | Overall | Follow-up | Overall | Follow-up | | | At end of overall application | At end of follow-up application | In summer of second year after last application |
| 5 | 1 | 800 sq.ft. | Sodium chlorate | Spray | Mid June, late July, early Sept. | 4 gal. 10% | 2 | 3 | 3 | 2 | F* | F* | — | 4 | 2 | 10 | 3 | 24 lb. | 90 | 1 | 0.5 | 1 |
| 6 | 1 | 300 sq.ft. | Sodium chlorate | Spray | ditto | 2 gal. 10% | 3 | F | F | F | F | — | — | 1 | 4 | 3 | 6 | 7 lb. | 95 | 1 | 0 | 0.25 |
| 8 | 1 | 1 sq. rod | Sodium chlorate | Sprinkle | June | 2 gal. 10% | 1 | 1 | F | F | F | F | F | 2 | 5 | 2 | 5 | 4 lb. | 75 | 3 | 0.25 | 0.25 |
| | 2 | 1 sq. rod | Sodium chlorate | Spray | June | 1 gal. 20% | 1 | 1 | F | — | — | — | — | 2 | 1 | 2 | 1 | 3.5 lb. | 75 | 1 | 0 | 0 |
| | 3 | 1 sq. rod | Sodium chlorate | Dry salt | June | 2 lb. | 1 | 1 | — | F | F | F | F | 2 | 4 | 2 | 4 | 5 lb. | 75 | 2 | 0.5 | 0.25 |
| | 5 | 1 sq. rod | Sodium chlorate | Spray | June and late July | 1 gal. 10% | 2 | F | F | F | F | — | — | 1 | 4 | 2 | 7 | 3 lb. | 95 | 1 | 0.25 | 0.5 |
| 9 | 11 | 1 sq. rod | Sodium chlorate | Spray | June | 1 gal. 10% | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 | — | 7 | — | 6.25 lb. | 90 | 3 | — | 5 |
| | 8 | 1 sq. rod | Sodium chlorate | Spray | July | 1 gal. 10% | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 | — | 7 | — | 6 lb. | 80 | 1 | — | 3 |
| | 9 | 1 sq. rod | Sodium chlorate | Spray | Early Aug. | 1 gal. 10% | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 | — | 7 | — | 7 lb. | 90 | 35 | — | 60 |
| | 10 | 1 sq. rod | Sodium chlorate | Spray | Early Sept. | 1 gal. 10% | 1 | 1 | — | 1 | 1 | 1 | — | 5 | — | 5 | — | 5 lb. | 85 | 70 | — | 70 |
| 12 | 1 | 1 sq. rod | Sodium chlorate | Dry salt | Nov. 6 | 0.5 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 0.5 lb. | 80 | 75 | — | 75 |
| | 2 | 1 sq. rod | Sodium chlorate | Dry salt | Nov. 6 | 1 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 1 lb. | 80 | 75 | — | 65 |
| | 3 | 1 sq. rod | Sodium chlorate | Dry salt | Nov. 6 | 1.5 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 1.5 lb. | 80 | 70 | — | 50 |
| | 4 | 1 sq. rod | Sodium chlorate | Dry salt | Nov. 6 | 2 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 2 lb. | 80 | 60 | — | 50 |
| 12 | 5 | 1 sq. rod | Sodium chlorate | Dry salt | Nov. 6 | 3 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 3 lb. | 80 | 20 | — | 25 |

TABLE 1.—EXPERIMENTAL DETAILS AND RESULTS OBTAINED WITH APPLICATIONS OF SODIUM CHLORATE, SODIUM CHLORIDE, AND PETROLEUM OILS TO POISON IVY—*Concluded*

| Exp. no. | Plot no. | Plot size | Herbicide | Applications | | | | | | | | | | | | Total amt. herbicides used | Poison ivy cover (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Mode | When made | Amt. applied in first application | No. per year | | | | | | | No. yrs. made | | Total no. | | | Before treatment | After treatment | | |
| | | | | | | | 1st year | 2nd year | 3rd year | 4th year | 5th year | 6th year | 7th year | Overall | Follow-up | Overall | Follow-up | | | At end of overall application | At end of follow-up application | In summer of second year after last application |
| 12 | 6 | 1 sq. rod | Sodium chlorate | Dry salt | Nov. 6 | 5 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 5 lb. | 80 | 10 | — | 10 |
| 8 | 4 | 1 sq. rod | Sodium chloride | Spray | Mid June, late July, early Sept. | 1 gal. 30% | 3 | 2 | 2 | 4 | 3 | — | — | 5 | — | 14 | — | 42 lb. | 85 | 13 | — | 60 |
| | 7 | 1 sq. rod | Sodium chloride | Sprinkle | ditto | 2 gal. 30% | 3 | 2 | 2 | 4 | 3 | — | — | 5 | — | 14 | — | 84 lb. | 85 | 3 | — | 10 |
| 10 | 14 | 1 sq. rod | Sodium chloride | Dry salt | June 20 | 10 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 10 lb. | 75 | 75 | — | 75 |
| | 13 | 1 sq. rod | Sodium chloride | Dry salt | June 20 | 20 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 20 lb. | 75 | 75 | — | 75 |
| | 12 | 1 sq. rod | Sodium chloride | Dry salt | June 20 | 40 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 40 lb. | 70 | 20 | — | 35 |
| | 15 | 1 sq. rod | Sodium chloride | Dry salt | June 20 | 60 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 60 lb. | 50 | 15 | — | 25 |
| 11 | 1 | 1 sq. rod | Sodium chloride | Dry salt | Oct. 7 | 20 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 20 lb. | 85 | 85 | — | 85 |
| | 2 | 1 sq. rod | Sodium chloride | Dry salt | Oct. 7 | 40 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 40 lb. | 85 | 85 | — | 85 |
| | 3 | 1 sq. rod | Sodium chloride | Dry salt | Oct. 7 | 60 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 60 lb. | 85 | 85 | — | 85 |
| | 4 | 1 sq. rod | Sodium chloride | Dry salt | Oct. 7 | 80 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 80 lb. | 85 | 85 | — | 85 |
| | 5 | 1 sq. rod | Sodium chloride | Dry salt | Oct. 7 | 100 lb. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 100 lb. | 85 | 85 | — | 85 |
| 8 | 6 | 1 sq. rod | Fuel oil | Sprinkle | Late June, early Sept. | 2 gal. | 2 | 2 | 2 | 2 | 3 | — | — | 5 | — | 11 | — | 21 gal. | 85 | 3 | — | 8 |
| 13 | 1 | ½ sq. rod | Kerosene | Spray | June and July | 1 gal. | 2 | — | — | — | — | — | — | 1 | — | 2 | — | 2 gal. | 90 | 65 | — | 90 |
| | 2 | ½ sq. rod | Kerosene | Spray | June | 1 gal. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 1 gal. | 90 | 75 | — | 90 |
| 14 | 1 | ½ sq. rod | Kerosene | Spray | June | 1 gal. | 1 | — | — | — | — | — | — | 1 | — | 1 | — | 1 gal. | 85 | 80 | — | 85 |

* F = Follow-up treatment.

(2) a sprinkle of 10% solution, and (3) a dry salt broadcast, reduced a stand of poison ivy from 75% to 1, 3, and 2% respectively. The spray application gave the best control but its advantage in reduction of the ivy present, over the other two methods, was not great. However, it was found that the follow-up treatment was more difficult and more prolonged on the plots treated with the sprinkling can or the dry salt, and as a result a larger amount of herbicide was required for complete eradication. It was difficult to secure a complete coverage with the sprinkling can on this size of plot. The large drops rolled off the leaves making it impossible to determine definitely which part of the plot had been treated, and consequently small areas were missed in the first application. Following treatment with the sprinkling can, the leaves turned brown in colour, became dry, curled, and crisp in a similar manner to those sprayed. With the dry salt applications the action of the herbicide on the poison ivy leaves was much slower. When applied as a solution to the foliage the leaves were usually dead within 5 to 7 days whereas, when the dry salt was applied to the ground, considerable green ivy foliage was present throughout the remainder of the summer.

*Dry Sodium Chlorate Applications in Late Fall.* (Table 1. Exp. 12, Plots 1–6.)

Single applications of from ½ to 5 pounds of sodium chlorate to plots of 1 square rod, made in November, yielded results in proportion to the amount of herbicide applied. Amounts up to 2 pounds decreased the poison ivy cover slightly but did not give satisfactory eradication. Applications of 3 and 5 pounds gave a fair control reducing the 80% stand to 20% and 10% respectively. These fall treatments had an adverse effect on the grass. Even the lightest application (½ pound per square rod) killed almost all of the grass present. As a result the plots were infested with such weeds as *Melilotus alba* Desr., *Nepeta Cataria* L., and *Chenopodium hybridum* L. in the summer following treatment. Previous to the treatment, grass was plentiful and there were only scattered plants of the above mentioned weeds present. In comparison, the June application of dry sodium chlorate, described under Mode of Application, was not nearly so severe on the grass.

*Concentration of Spray Solution.* (Table 1. Exp. 8, Plots 2 and 5.)

A comparison of the effect of concentration of sodium chlorate spray was obtained by making applications in June of 1 gallon of 10% and 20% solution, respectively, to plots of 1 square rod in area. By late August the plot receiving the 10% solution had a 35% cover of green poison ivy, which had developed since the herbicide was applied. It was given a second application at this time. As a result, less than 1% ivy was still present the following spring and only follow-up treatments were required. The plot receiving the 20% solution had a 10% cover present in late August, but was not given a second application. By the following June, there was only 2% ivy cover so less than ½ gallon of spray was required for this second treatment. Therefore, in this experiment, when 1 gallon was sprayed on 1 square rod, a rather light application, there was little difference between one treatment per year of 20% solution or two treatments per year of 10% solution.

*Time of Year to Treat with Single Application.* (Table 1. Exp. 9, Plots 8–11.)

One application per year for 7 successive years of 1 gallon 10% sodium chlorate sprayed on square rod plots in the months of (1) June, (2) mid July, (3) early August, and (4) early September, reduced a stand of poison ivy from an average 85% cover to 3, 1, 35, and 70% respectively. The September treatment, made when many of the poison ivy leaves had fallen and the remainder had assumed their reddish or yellow fall colouring, had no noticeable effect on the stand of poison ivy. This was so evident that discontinuance of this treatment was decided upon in the 3rd year, and no application was made. Further treatments made in the 4th, 5th, and 6th years confirmed this conclusion. The treatments made during the first week in August did not reduce the stand of poison ivy sufficiently to give a satisfactory control. The June and July applications reduced the stand of poison ivy gradually (see Table 2) until, at the end of the 7th year, only a few small scattered clumps remained. Although the July

TABLE 2.—EFFECTS OF SODIUM CHLORATE SPRAY ON POISON IVY*

| Month of treatment | Percentage cover of poison ivy at time of treatments, and in the month of July for two years following treatment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year of treatment | | | | | | | Year following treatment | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 |
| June | 90 | 30 | 45 | 25 | 8 | 7 | 5 | 3 | 5 |
| Mid July | 80 | 70 | 25 | 25 | 10 | 5 | 4 | 1 | 3 |
| Early August | 90 | 85 | 60 | 50 | 40 | 40 | 40 | 35 | 60 |

* Percentage cover of poison ivy on square rod plots receiving 1 application per year for 7 successive years of 1 gallon of 10% sodium chlorate sprayed on the foliage during (1) June, (2) mid July, and (3) early August.

treatment gave a somewhat better control than that made in June, it is not considered that this difference was due to time of treatment. The plot sprayed in June was in close proximity to a railroad with the result that a part of the plot was cut each year about the time application was made. Most of the ivy that was present at the conclusion of this experiment was concentrated on this part of the plot. From this experiment it is evident that if only 1 application can be made a year best results will be obtained from treatment made in June or early July. The experiment investigating concentration of spray solution suggests that fewer applications would have been required if a larger amount of herbicide had been used than 1 pound per square rod.

*Spray.* (Table 1. Exp. 6.)

The results obtained in the following experiment, when sodium chlorate solution was sprayed on poison ivy foliage, are representative for all the plots receiving this type of treatment. The area consisted of 300 square feet of dense poison ivy (95% cover). The ground was quite rough with a brush heap in the central area and a loose pile of stones to one side. Both of

these were completely overgrown with poison ivy. On the back or eastern portion of the plot, in the vicinity of a large stump, the ivy stems were much larger, higher, and not so numerous as on the front section. All applications were made using a knapsack sprayer with 10% solution of sodium chlorate. Details of treatments and the results obtained were as follows.

1936

June 5. The 95% stand of poison ivy was sprayed with 2 gallons of solution (Plate I, Figure 2).

June 12. The majority of the poison ivy leaves were dry, curled and brownish in colour. Where the ivy was thickest, however, some of the lowermost leaves were still normal in appearance and green in colour. At this time, these normal leaves were sprayed with one gallon of solution.

June 25. The poison ivy leaves were all brown, curled and dead (Plate I, Figures 3 and 4). There was evidence of regrowth on the stone pile (Plate II, Figure 1).

July 27. Sufficient new growth had appeared to give a 60% stand of poison ivy (Plate II, Figure 2). Recovery was not uniform over the whole plot, however, being more marked in the vicinity of the brush and stone piles where the original plants were shorter with smaller upright stems (Plate II, Figures 3 and 4). The area was given a second overall application with 2 gallons of solution.

July 30. The leaves of the sprayed plants were dry, curled, light green in colour and dying.

Aug. 13. New growth poison ivy was re-appearing on part of the area.

Aug. 26. The area as a whole had a 5% cover of poison ivy. The plants present were concentrated in one-quarter of the plot and consisted of small isolated clumps (Plate III, Figures 1 and 2). The area was given its third application with 3/4 of a gallon of solution.

Sept. 14. The leaves of the poison ivy treated on August 26 were all dead. The area appeared free of poison ivy (Plate III, Figure 3) but close examination revealed a few very small clumps. Some were in areas not treated on August 26, so had appeared since that time.

1937

June 22. Only 8 small clumps of poison ivy (less than 1% coverage) were found (Plate III, Figure 4). These ivy plants were sprayed with sodium chlorate.

July 12. The 8 clumps of green poison ivy present at this time were sprayed with sodium chlorate. Some of these clumps had appeared since the June 22 treatment as they were in different parts of the area.

Sept. 2. The 10 small clumps of poison ivy present were sprayed with sodium chlorate.

June 28, 1938. One small clump of poison ivy was found. It was sprayed with sodium chlorate.

Aug. 8, 1939. The 3 small clumps of poison ivy that were present were sprayed with sodium chlorate.

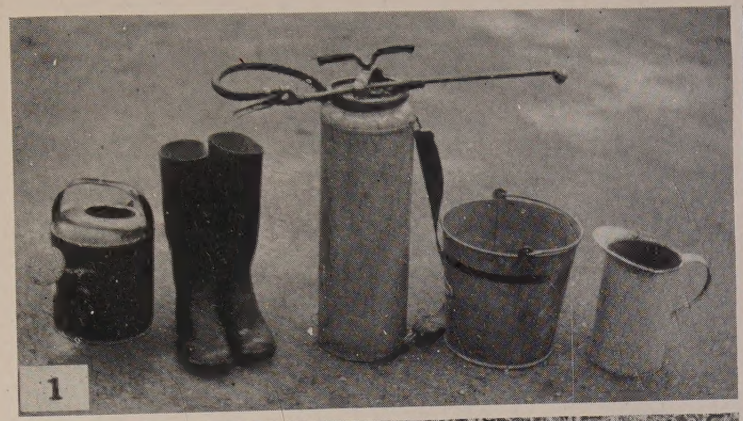

FIGURE 1. The equipment used in eradication experiments with poison ivy.—The illustrations from Plate I, Figure 2, to Plate III, Figure 4 inclusive, give a photographic record of the eradication of poison ivy on plot 1, experiment 6, when sprayed with 10% sodium chlorate. (Further details given in text.) FIGURE 2. General view of a part of the plot taken on June 5, 1936, immediately before the first application of sodium chlorate spray. There was an estimated 95% cover of poison ivy. FIGURE 3. General view of the same plot on June 25, 1936, 20 days after the first application of spray. The poison ivy leaves were all brown, curled, and dead. FIGURE 4. Close-up view of dead poison ivy plants on June 25, 1936, 20 days after the first application of spray. The dead leaves as well as the previous year's fruit still attached to the old stalks.

FIGURE 1. There was evidence of recovery on June 25, 1936, 20 days after the first application as can be seen by the new green leaves circled in the foreground. FIGURE 2. General view of the plot on July 27, 1936, 52 days after the first application and at the time of the second treatment. A 60% cover of poison ivy leaves had been produced since the first application. FIGURE 3. Close-up view on July 27, 1936, of the central portion of the plot showing the area in which the new green leaves were the thickest. FIGURE 4. The recovery of the poison ivy was not uniform over the whole plot however, as shown by this close-up view on July 27, 1936, of the back portion of the plot. A large number of dead stalks were visible but only 1 new green shoot. There was very little recovery of poison ivy on this part of the plot.

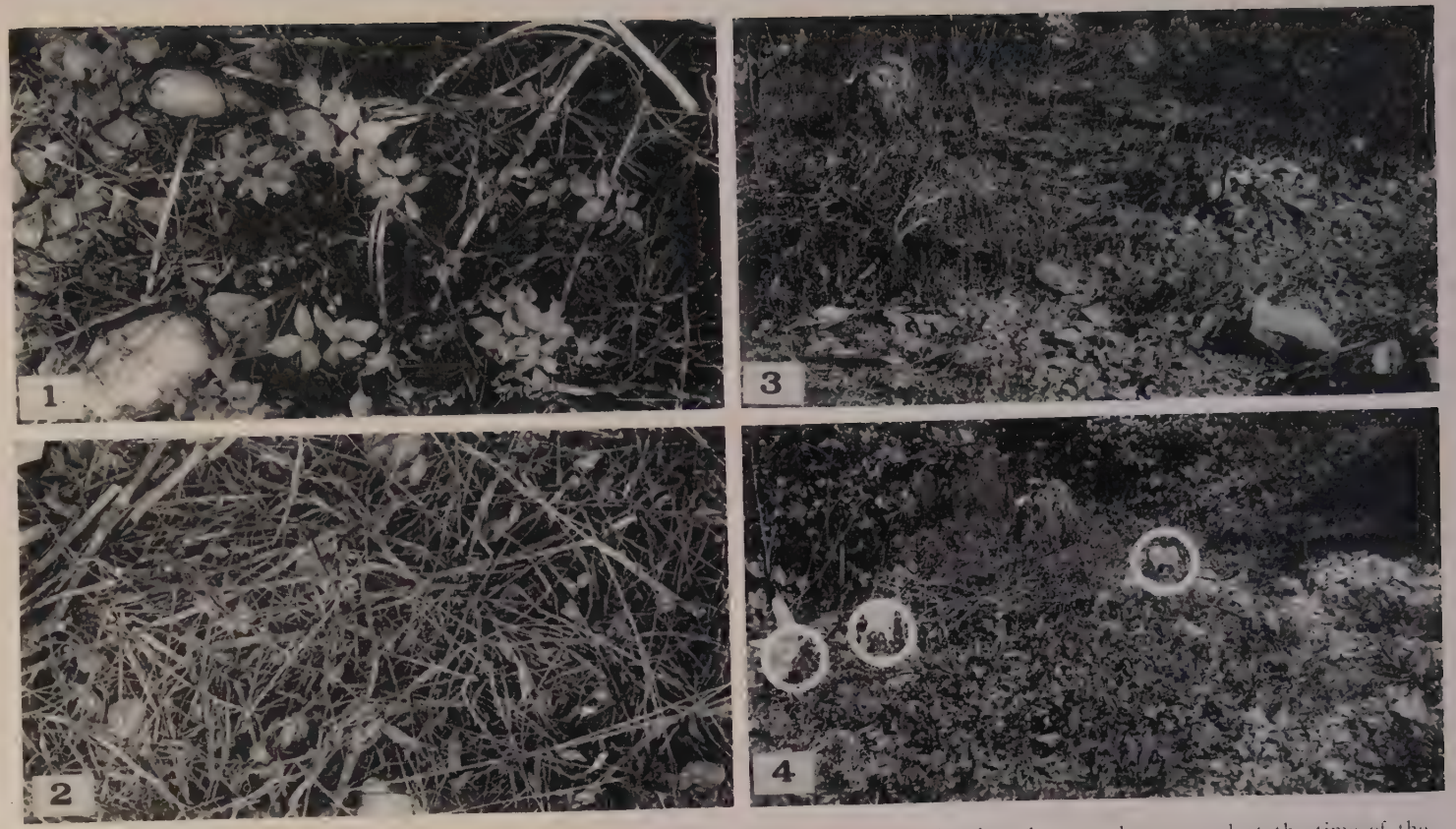


FIGURE 1. Close-up view of the central part of the plot on August 24, 1936, 4 weeks after the second spray and at the time of the third application. The 5% cover of poison ivy consisted of small scattered clumps concentrated on approximately one-quarter of the plot. FIGURE 2. Close-up view of the back portion of the plot on August 24, 1936, 4 weeks after the second application. No new green poison ivy leaves were to be found on this portion of the plot. FIGURE 3. General view of the plot on September 30, 1936, 5 weeks after the third application of spray. There was less than 1% cover of poison ivy with the plants so small and scattered that they cannot be seen in the photograph. FIGURE 4. General view of plot on June 15, 1937, the summer following the three applications of sodium chlorate spray. Three small clumps of poison ivy were visible on this part of the plot.

July 12, 1940. Two clumps of poison ivy were present. They were sprayed with sodium chlorate.

June 12, 1941. No poison ivy was found on the area.

Aug. 24, 1945. Three isolated clumps of poison ivy were present on the plot, each consisting of 2 or 3 upright stems. Therefore, a complete eradication was not obtained from the 5 years of spray treatments.

## DISCUSSION

While poison ivy no doubt can be killed with persistent and continued use of common salt (sodium chloride) or furnace fuel oil, the results obtained in these experiments were far from impressive. In no case was a complete eradication obtained. With applications of dry common salt, large quantities must be used and in applications of solution to the foliage by means of sprayer or sprinkling can, oft-repeated treatments are required. Under conditions of these experiments, with shallow soil over limestone substratum, a better and more economical control was obtained with sodium chlorate. Dense stands of poison ivy were reduced to from 1 to 3% cover in one year with the chlorate herbicide. As a follow-up treatment, however, in eradicating these small scattered clumps, spraying the foliage with sodium chlorate was not satisfactory. At least 3 or 4 years of treatment were required and in some cases, 5 years did not completely remove them. The poison ivy leaves were killed by each application of spray but apparently the roots survived and put forth new growth, since many of the clumps kept re-appearing each year. Willard (23), in discussing the killing effect of chlorate sprays, states that destruction of the plant depends on getting a killing concentration of chlorate in the soil around the poison ivy roots. Pavlychenko (17), while investigating the herbicidal action of sodium chlorate on Canada thistle, could not find any evidence that chemicals in solution of herbicidal concentration are transported from the leaves to the root system. He considered that destruction of underground parts of perennial weeds was due to "producing a durable sterility of the top soil". Therefore, the application of an excess amount of dry sodium chlorate around the base of the stems or digging out bodily the few remaining clumps of poison ivy would no doubt have yielded better results than the continued spraying of the foliage.

## SUMMARY AND CONCLUSIONS

1. Sodium chlorate, sodium chloride, furnace fuel oil, and a water white kerosene were investigated as herbicides for the eradication of poison ivy. Methods of treatment included application of solution to the foliage by means of a knapsack sprayer or sprinkling can, and dry salt broadcast by hand.

2. Poison ivy can be eradicated with sodium chlorate if treatment is persistent and thorough.

3. Common salt and furnace fuel oil are not considered satisfactory herbicides for the eradication of poison ivy. Because of repeated applications, large quantities were required even to reduce a dense stand to a light infestation. This resulted in greater expense and more labour than with chlorates.

4. Water white kerosene when applied as a spray to the foliage, proved of no value in eradicating poison ivy.

5. Three applications of 10% sodium chlorate solution, sprayed on the leaves at the rate of 1 gallon per square rod, with the first treatment made in June as soon as leaves are fully expanded, the second in late July, and the third in September, reduced dense stands of poison ivy to a few scattered plants.

6. Results obtained indicate that fewer overall applications of spray would be required during the year, if larger quantities of chlorate were applied than 1 pound per square rod.

7. Applications of sodium chlorate made as a solution with a sprinkling can or as the dry salt broadcast gave almost as good an initial kill as when sprayed on the leaves, but follow-up treatments were more difficult and larger quantities of herbicide were required to give equal results.

8. Spraying the foliage with sodium chlorate was not satisfactory as a follow-up treatment in eradicating the small scattered clumps of poison ivy that kept re-appearing in the years following the initial application.

9. With only 1 application a year, of 10% sodium chlorate solution sprayed on the leaves in June or early July at the rate of 1 gallon per square rod, 7 years of treatment were required to reduce a dense stand of poison ivy to a few scattered clumps. Similar applications in August or September had little or no effect on the poison ivy.

## ACKNOWLEDGMENTS

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# AN IMPROVED METHOD OF ROOTING ALFALFA CUTTINGS[1]

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Both in the testing for seed and forage yield and in breeding programs with alfalfa it is frequently necessary to propagate plants vegetatively. If the breeding system proposed by Kiesselback, Tysdal, and Westover (2) proves feasible, large numbers of cuttings will be required. An efficient technique of propagation is therefore of great importance.

The technique previously used at Saskatoon and probably fairly generally used elsewhere was to place sections with two nodes from fairly mature stems in sand and keep the sand moist. Only 1 or 2 leaves were usually left on the cuttings. At Saskatoon this technique has on the average given a low percentage of rooted cuttings. From some plants the rooting success was fairly high while other plants were almost impossible to propagate vegetatively by this method. As an average of a large proportion of plants not over 30 to 40% of the cuttings made would root.

Faced with the assignment of making a large number of cuttings in the spring of 1945, Mr. F. Rose, greenhouse foreman at the Dominion Forage Crops Laboratory, began experimenting with various procedures in the winter of 1944–45. From his studies a technique has been evolved which has been found to be very satisfactory. The procedure simply consists of standing stem sections in slowly running water. While the influence of such variable factors as air and water temperatures, light, etc., on the success of this method have not been critically studied, the high degree of success with fairly large populations under varying environmental conditions warrants publication of the method.

The equipment required consists of galvanized sheet iron troughs the dimensions of which may be varied to suit a variety of conditions. The ones used to date have been 4 or 5 feet long and 2 inches wide and 2 inches deep. One end of the trough is closed and into this end is fed a slowly flowing stream of water. The other end of the trough is left open and either the sheet iron in the bottom of the open end is raised about $\frac{1}{8}$ to $\frac{1}{4}$ inch or that end of the trough is set up on a thin block in order to maintain the water at a level of about $\frac{1}{8}$ to $\frac{1}{4}$ inch. Near the top along each side of the trough a row of holes about $\frac{1}{8}$ inch in diameter and about $1\frac{1}{2}$ inch apart is drilled. A second row of holes is drilled about $\frac{3}{4}$ inch below and slightly offset from the top row. Through these holes pieces of galvanized wire are inserted. A loop on one end of these wires and a slight bend in the other end holds them in place and yet permits their withdrawal when desired. These wires serve as supports to hold the stem cuttings upright and also serve to separate cuttings from different plants. By providing a multiple lead in for the water a battery of troughs may be operated at one time.

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The temperature of the water used at Saskatoon has been around 60° F. While it is probable that water temperature would influence both the success and rapidity of rooting, this has not been studied as yet.

Around 50 cuttings may be placed in a 1.5 inch section of the 2 × 2 inch trough. In order to provide for aeration and for light penetration the practice has been to leave alternative sections of the trough blank when as many as 40 or 50 cuttings were placed in a section. This practice may or may not be of importance but good results have followed its use.

Sanitation in the troughs is obviously important. After a batch is removed from a trough it is advisable to scrub it out thoroughly and to use a mild disinfectant. The problem of sanitation has been found to be much more serious in wooden troughs and for this reason their use is not recommended.

Stem sections need only to consist of one node and an internode. Thus more cuttings can be obtained than in the case of the moist sand technique where sections consisting of 2 nodes are used. The stems are cut just above the nodes and the lowermost cut surface is inserted in the water in the trough. It has been observed that fairly mature healthy vigourous stems give a higher proportion of successful rooting than succulent young stems. The statement by Garner (1) that "cuttings should be rich in stored food (carbohydrates)" may be the explanation of the above observation. Fully mature stems which have shed at least some of their leaves should be avoided if possible. It has been observed that there is a positive correlation between the abundance of healthy leaves on the cuttings and the vigour and rapidity of rooting. In this connection Garner (1) states that "leaves on stem cuttings are a definite advantage, their absence may preclude rooting".

The majority of cuttings in running water will send out roots in from 10 to 15 days. The roots generally develop from the cut surface, although occasionally when the cut end is diseased or injured they will be initiated a short distance up on the cutting. In contrast, with the moist sand technique a portion of the lower end of the cutting usually dies and the roots emerge from higher up on the cutting. This results in slower rooting. Practically as soon as the roots appear the practice has been to place the cuttings in soil. When the roots are allowed to develop in the water to more than $\frac{1}{8}$ to $\frac{1}{4}$ inch in length it becomes more difficult to plant them in soil without injury. Experience has shown that there is a very low mortality in transferring from the water directly to the soil. There is thus no need of using a moist sand culture as an intermediate step.

While no extensive comparisons have been made with the formerly used moist sand culture a limited study was conducted. Four mature plants were selected and 4 stem sections from each plant were placed in each of moist sand and running water. Alternative sections from a stem were placed in the two media. The results are recorded in Table 1.

The success of rooting in moist sand as shown in Table 1 is fairly typical of past extensive experience. The superiority of the running water technique in this small test is very pronounced and as will be shown later the degree of success in this test if anything was low compared to more extensive experience. The results in the above test are illustrated in Figure 1.

TABLE 1.—COMPARATIVE ROOTING OF STEM SECTIONS FROM FOUR PLANTS IN RUNNING WATER AND IN MOIST SAND

| Plant designation | Running water | | Moist sand | |
|---|---|---|---|---|
| | No. of cuttings made | No. of cuttings rooted | No. of cuttings made | No. of cuttings rooted |
| A | 5 | 4 | 5 | 1 |
| B | 5 | 3 | 5 | 0 |
| C | 5 | 5 | 5 | 0 |
| D | 5 | 5 | 5 | 0 |
| Total | 20 | 17 | 20 | 1 |

FIGURE 1. Comparative rooting 19 days after making cuttings from Plant C of Table 1. On left four sections kept in moist sand and on right four kept in running water. Note that leaves on sections in sand are practically all dead while those from running water are practically all living.

Fairly extensive use was made of the running water technique in the spring of 1945. From March 29 to April 2 there were 2043 cuttings made from 23 different plants of which 1835 or 89.8% rooted in from 11 to 17 days. Evidence of the influence of stage of development and vigour of the plant on successful rooting is indicated by the fact that of 657 cuttings made from 7 plants which were fairly mature and vigourous 637, or 97%, rooted, whereas from 10 plants which were noticeably weaker only 755 rooted cuttings, or 88%, were obtained from 854 attempted.

## ACKNOWLEDGMENTS

Development of the technique described above is very largely due to the ingenuity and initiative of Mr. F. Rose and the author gratefully acknowledges his very valuable contribution.

## SUMMARY

1. A method of rooting stem sections of alfalfa in running water is described.

2. Using mature stems, cuttings are made consisting of one node and the internode.

3. The cuttings are placed upright in slowly running cool water in galvanized iron troughs which are separated into sections with galvanized iron wire.

4. The size of the troughs used were 4 feet long, 2 inches wide, and 2 inches deep although this may be varied to suit convenience.

5. Rooting occurred on 85 to 97% of cuttings placed in running water compared to a maximum of 30 to 40% previously obtained in moist sand.

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# CORRELATED INHERITANCE OF STEM RUST REACTION, NITROGEN CONTENT OF GRAIN AND KERNEL WEIGHT IN A BARLEY CROSS[1]

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The objective of the present barley breeding program in The University of Manitoba is the production of a stem rust resistant, smooth awned variety with good malting quality. In order to facilitate the breeding procedure, it is necessary to understand the mode of inheritance and the inter-relationship of the characters involved.

Criteria of malting quality were studied rather than actual malting quality characteristics for several reasons. The criteria studied, namely barley nitrogen content and kernel weight, are used by the plant breeders to eliminate undesirable hybrids in early generations after the cross. The determination of these criteria requires a much smaller sample of grain and much less time and equipment than actual malting tests.

As nitrogen content and kernel weight are indicators of malting quality, their relationship to stem rust resistance is important in a breeding program the object of which is stem rust resistant malting barley.

If nitrogen content and kernel weight are genetically independent of the factor or factors for stem rust reaction, no difficulty should be encountered in obtaining the desired combinations of the above quality factors with stem rust resistance. However, from examination of the malting data on many stem rust resistant hybrids, it appears the above combination is difficult to obtain.

## REVIEW OF LITERATURE

Studies involving the inheritance of stem rust reaction in barley have been few.

Shands (10) reported in 1939 that Chevron (C.I. 1111) was selected and named at Chico, California in 1918 from seed originally obtained at the Swiss Seed Experimental Station, Zurich, Switzerland. Peatland (C.I. 5267) was selected from part of the same original lot at the Minnesota Agricultural Experimental Station in 1916.

Shands (10) found Chevron resistant to stem rust (*Puccinia graminis tritici*, Eriks. and Henn.) under severe epidemics in 1935 and 1937. In 1937 it showed an average of 1% stem rust. The resistance of Chevron was shown to be dominant and due to a single factor in crosses with Wisconsin Pedigree 38, Velvet and two smooth awned hybrids ×152 and ×169. A cross of Oderbrucker × Chevron gave the same result.

Mains and Martini (7) found Chevron to be highly resistant to three physiologic races of mildew (*Erysiphe graminis hordei*, March) and highly susceptible to leaf rust (*Puccinia anomola*, Rostr.). Tidd (12) showed it to be highly resistant to races 6 and 7 of barley mildew.

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[1] A thesis submitted to the Committee on Graduate Studies at The University of Manitoba in partial fulfilment of the requirements for the Degree of Master of Science.

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Immer *et al.* (6) found Chevron resistant to 18 races and susceptible to one race of stem rust in the seedling stage. They also found that seedling reaction could be used as a test for adult plant reaction.

Power and Hines (8), in a Peatland × Glabron cross, found resistance to stem rust dominant and due to a single factor pair Tt. The factors for stem rust reaction and barbing of the awns were not linked. Reid (9) obtained a similar result in a cross of Barbless and Peatland.

Brookins (3) working with Peatland, located the factor pair Tt for stem rust reaction in the seventh linkage group. He found that seedling reaction to races 19, 39 and 56 was monohybrid with resistance dominant. The same factor pair controlled mature plant reaction to a large number of physiologic races.

Shands (11) in a study to determine what constituted an adequate sample for 1,000 kernel weight, found 400 kernels to be sufficient for accuracy.

Anderson *et al.* (1) demonstrated that within varieties there is a negative correlation between total barley nitrogen and malt extract, and a positive correlation between total barley nitrogen and each of the characters diastatic activity, malt loss, wort nitrogen, proteolytic activity, and starch liquefying power, in the malt. The simple correlations between total barley nitrogen and wort nitrogen, malt extract, diastatic activity, and proteolytic activity were significant beyond the 1% point. They also found that kernel weight, within varieties, was significantly and positively correlated with hours to steep and malt extract. Kernel weight, within varieties, was significantly and inversely correlated with wort nitrogen, and starch liquefying activity.

Anderson *et al.* (2) pointed out that the barley variety O.A.C. 21 is the most suitable variety in Canada for malting purposes. In the descriptions given by them with reference to malting quality, O.A.C. 21 is described as having a medium sized kernel and medium nitrogen content over a wide range of environmental conditions. Its malt extract, diastatic activity, and wort nitrogen are high. Little loss in extract occurs during malting. It produces a mellow well modified malt with a maximum of extractives.

In the same paper, Chevron is faulted on account of a very high nitrogen content, very low kernel weight, and percentage heavy grade barley. These faults result in low extract although enzymatic activity is good.

Peatland, a sister selection of Chevron, appears to be better than Chevron, but not equal to O.A.C. 21 in either kernel or malt characters.

## MATERIAL AND METHODS

O.A.C. 21 was selected as the susceptible parent because it is the standard of quality for six-row malting barley in Canada. It is a good yielding, rough-awned, six-row, blue aleurone variety.

For the resistant parent there were two alternatives, Chevron or Peatland. Chevron was chosen because it is poorer in quality than Peatland, especially in the two quality factors being studied. It was thought that the greater the contrast between the parents, the more chance there would be of obtaining clear-cut information. Chevron is generally low in yield. It is a rough-awned, six-row, white aleurone variety.

The cross O.A.C. 21 × Chevron was made in the field in 1941. An $F_1$ population was produced in the greenhouse during the following winter. At the same time a backcross was made to the recessive parent. (O.A.C. 21 was known to be the recessive parent from observations on previous crosses of the same nature.) The material available for field planting in 1942 was as follows; 25 $F_0$ seeds, 29 backcross seeds, and seed from 20 $F_1$ plants grown in the greenhouse. The above along with both parents were subjected to an artificial epidemic of a large number of races of stem rust.

In the fall, all of the plants were pulled and taken inside for stem rust readings. A total of 592 $F_2$ plants were obtained. After rust readings were made 200 $F_2$ plants were selected at random to produce an $F_3$ population.

The seed of each of the 200 plants was divided into two lots. Twenty-five kernels, taken at random from each plant, were placed in one lot to be used for determination of stem rust reaction and genotype of the line. The remaining seed of each $F_2$ plant comprised the lot for use in the quality studies.

In 1943 the lot chosen for determination of rust reaction was subjected to an artificial epidemic of stem rust in the field. The other lot, for quality studies, was planted at another location. Each line was planted in a single row and at 10-row intervals the parents were planted. The planting for quality determinations was dusted with sulphur to prevent infection by stem rust. In this way the rust resistant and susceptible genotypes, which could be identified from their counterparts in the artificially infected plot, could be studied and compared as regards their quality factors without having the latter influenced and the comparison disturbed by the presence or absence of rust.

Stem rust readings for all material were made on a percentage basis (Clark *et al.*, 4). The percentage interval was 10. Among the $F_3$ lines those showing zero or trace on all plants were classified as resistant. The lines showing more than 10% on all plants were rated as susceptible. Those showing both resistant and suceptible plants were classified as segregating.

Thousand kernel weight was determined by counting 500 kernels at random from each $F_3$ line.

Duplicate nitrogen determinations on an oven dry basis were made by the Grain Research Laboratory, Winnipeg, for each $F_3$ line.

Statistical methods used were as described by Goulden (5).

## RESULTS AND DISCUSSION

### 1. Inheritance of Stem Rust Reaction

Table 1 reveals that resistance to stem rust is dominant because all of the $F_1$ plants are resistant. The resistant hybrids, however, appear to be less resistant than the resistant parent. Chevron, the resistant parent, had 61.1% of its plants in the trace group (the remaining 38.9% in the zero group), while in the $F_1$, 94.7% were in the trace group. In the backcross resistant class, 100% were in the trace group, and in the $F_2$ resistant class 87.7% were in the trace group. The higher percentages of plants in the trace group in the hybrid offspring suggest that one or more modifying

factors are present. This slightly influences the progeny towards susceptibility. However, the modifying factor or factors do not have enough influence to take any plant out of the resistant class or to be of practical significance.

TABLE 1.—STEM RUST REACTION OF THE PARENTS, $F_1$, BACKCROSS AND THE $F_2$ IN THE CROSS O.A.C. 21 × CHEVRON

| | Stem rust infection in per cent | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | t | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | |
| O.A.C. 21 | | | | 1 | 4 | 9 | 6 | 9 | 3 | 1 | 33 |
| Chevron | 14 | 22 | | | | | | | | | 36 |
| $F_1$ | 1 | 18 | | | | | | | | | 19 |
| Backcross | | 14 | 1 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 26 |
| $F_2$ | 53 | 368 | 14 | 18 | 38 | 36 | 32 | 21 | 9 | 3 | 592 |

In order to classify the $F_2$ offspring of the cross as resistant or susceptible to stem rust, the breeding behaviour of 194 $F_2$ plants was studied in the $F_3$. All of the plants, except 2, which showed zero or trace in the $F_2$ were either resistant or segregating in the $F_3$. The two lines that were neither resistant nor segregating showed 40% stem rust. The parent plants of these two lines probably escaped full infection in the $F_2$. It would appear, therefore, that in classifying all $F_1$, backcross and $F_2$ plants showing zero or trace as resistant, the error in classification is so small as to have no appreciable effect on the genetic ratios obtained. The plants that showed 20% or more rust in $F_2$ when grown in the $F_3$ all showed a heavy infection of rust. All backcross and $F_2$ plants that showed 20% or more rust can therefore be classified as susceptible.

The 15 plants showing 10% stem rust were grown for classification. The plant from the backcross was resistant. Of the 14 $F_2$ plants showing 10% rust 11 were resistant and three were susceptible.

TABLE 2.—SUMMARY OF STEM RUST REACTION OF THE PARENTS, $F_1$, BACKCROSS AND $F_2$ IN THE CROSS O.A.C. 21 × CHEVRON

| | Resistant | | Susceptible | | Theor. ratio | Chi-Square | Probability |
|---|---|---|---|---|---|---|---|
| | Actual | Theor. | Actual | Theor. | | | |
| O.A.C. 21 | 0 | | 33 | | | | |
| Chevron | 36 | | 0 | | | | |
| $F_1$ | 19 | | 0 | | | | |
| Backcross | 15 | 13 | 11 | 13 | 1 : 1 | 0.62 | 0.50 – 0.30 |
| $F_2$ | 432 | 444 | 160 | 148 | 3 : 1 | 1.30 | 0.30 – 0.20 |

Table 2 shows the summarized and corrected classification of the data from Table 1. The fit of the actual to the theoretical ratios in the backcross and the $F_2$ population is respectively very good. This is especially true of the backcross where it is shown that a deviation from the 1 : 1 ratio, as great or greater than that found, would be expected by chance in from 30 to 50% of the cases. In the $F_2$ the corresponding deviation from the 3 : 1 ratio would be expected in from 20 to 30% of the cases.

Of the 194 $F_3$ lines grown, 46 were resistant, 94 segregated and 54 were susceptible. When these results were fitted to a 1 : 2 : 1 ratio, Chi-square was 0.79 with $P$ between 0.70 and 0.50. This obviously is an excellent fit.

In view of the above results, it may be concluded that the inheritance of the degree of susceptibility and resistance to stem rust, exhibited respectively by O.A.C. 21 and Chevron, is governed by a single pair of factors with resistance dominant. Since Chevron and Peatland are sister selections, it seems reasonable to assume that they have identical genotypes for stem rust resistance. This factor has been designated as Tt by Powers and Hines (8). It was found by Brookins (3) to be in the seventh linkage group. If the factor is Tt then the genotype of O.A.C. 21 for stem rust reaction is tt and for Chevron TT.

Figures 1 and 2 show the amount of stem rust present in typical plants of the parents, $F_1$ and $F_2$.

## 2. Quality Studies

### A. *Inheritance of Nitrogen Content*

In the $F_3$ generation of the cross, 187 of the 200 lines sown produced enough seed for quality determinations. The lines used for this purpose are those grown in the plot where stem rust infection was prevented. Nitrogen content was determined for each line as described previously. The stem rust reaction of the lines was known since a sample of each line was exposed to stem rust infection in a separate nursery. Thus, the genotype with regard to stem rust reaction, was known for each line.

Table 3.—Frequency distribution of nitrogen content in per cent for the parents and the different genotypes in the $F_3$

| | Percentage nitrogen | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2.145 | 2.245 | 2.345 | 2.445 | 2.545 | 2.645 | 2.745 | 2.845 | 2.945 | 3.045 |
| O.A.C. 21 | 1 | 0 | 6 | 12 | 2 | | | | | |
| Chevron | | 2 | 0 | 1 | 6 | 8 | 3 | 1 | | |
| Parent Totals | 1 | 2 | 6 | 13 | 8 | 8 | 3 | 1 | | |
| $F_3$ Susc. | 1 | 3 | 8 | 13 | 14 | 4 | 8 | 2 | 1 | |
| $F_3$ Seg. | | 4 | 8 | 18 | 21 | 13 | 13 | 8 | 4 | 1 |
| $F_3$ Resis. | 1 | 1 | 2 | 5 | 12 | 12 | 5 | 1 | 3 | 1 |
| $F_3$ Totals | 2 | 8 | 18 | 36 | 47 | 29 | 26 | 11 | 8 | 2 |

The $F_3$ data presented in Table 3 indicate transgressive segregation for nitrogen content. When the combined distribution of the $F_3$ groups is compared to the combined distribution of the parents, 10 (or 5.35%) of the $F_3$ lines exceeded the parents in nitrogen content. It is interesting to note that the $F_3$ segregating group, as would be expected, has the complete range of nitrogen content (with the exception of the lowest class, in all probability missed due to chance) exhibited by the combined resistant and susceptible $F_3$ groups.

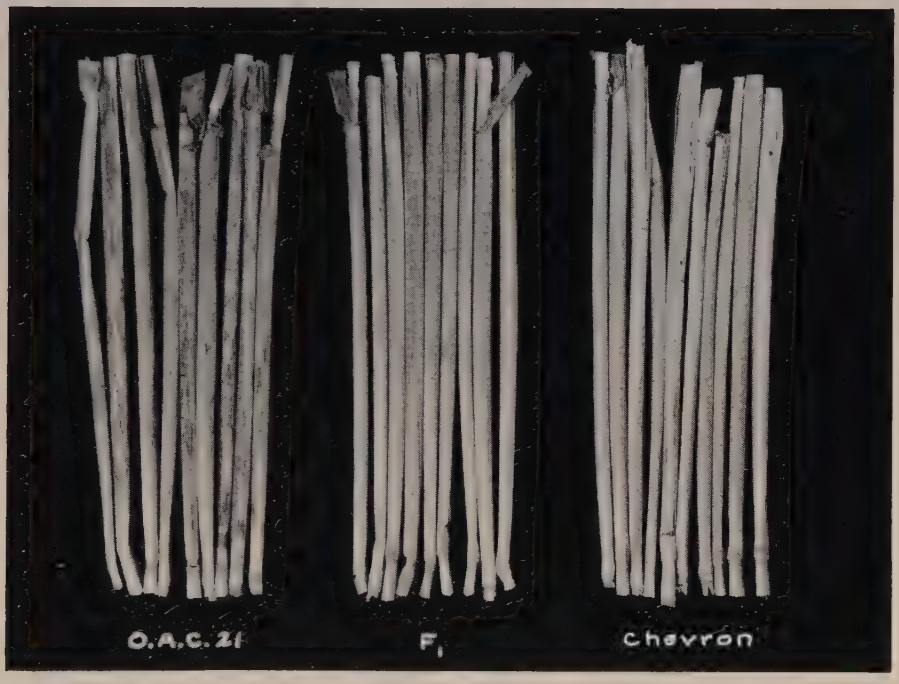


FIGURE 1. Stem rust infection on the parents and $F_1$.

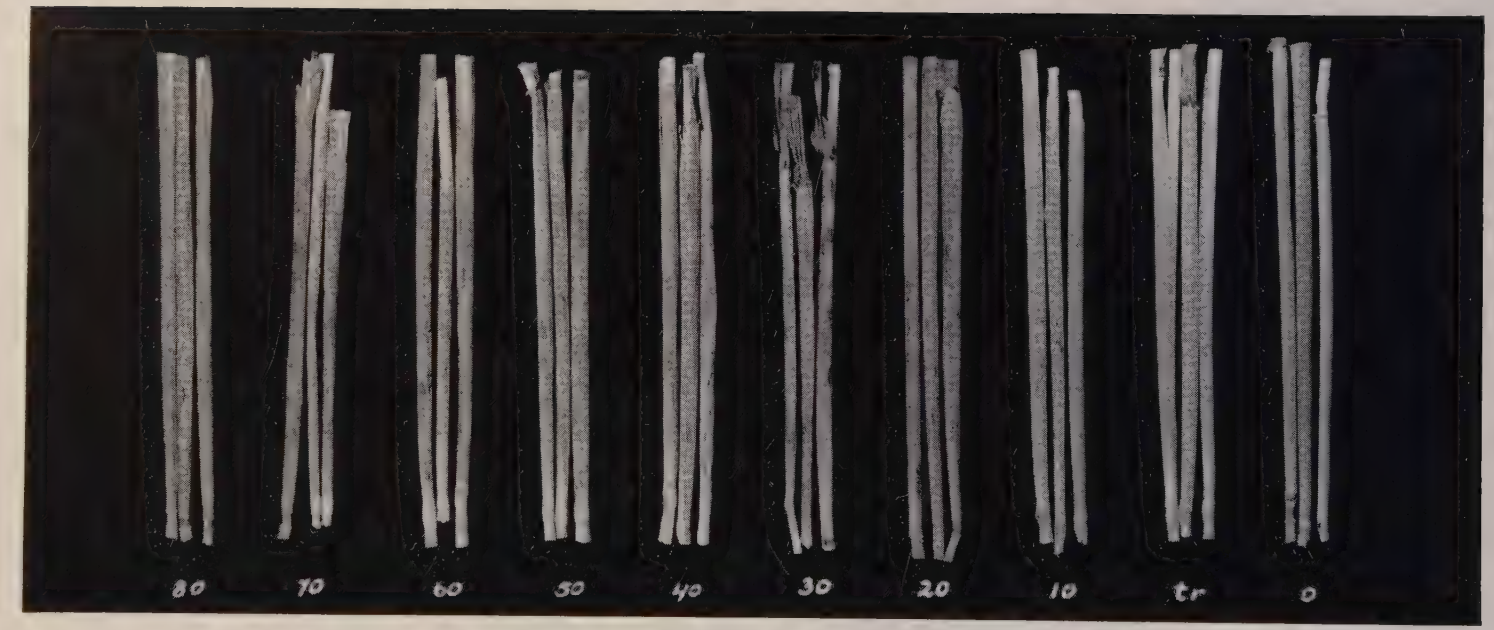


FIGURE 2. Range of stem rust infection on $F_2$ plants in per cent.

If transgressive segregation has occurred, lines lower in nitrogen content than the parents would be expected. However, results similar to these are obtained repeatedly in breeding programs when an attempt is made to increase or decrease a quantitative character if the maximum or minimum limit is being approached. A good example of this is yield. Two high yielding types are often crossed and the resulting progeny almost invariably have many lower yielding lines and very few or no higher yielding lines. The same can be said for nitrogen in the present study. Within the genetic limits represented by the parents involved, O.A.C. 21 is probably nearer the lower limit for nitrogen content than Chevron is near the upper limit. Consequently there is a tendency toward high nitrogen in the progeny of this cross.

In view of this definite tendency we would expect to have more $F_3$ lines with higher nitrogen content, in relation to the parents, than lines with lower nitrogen content. The population studied was small and as only 10 lines out of 187 exceeded the resistant parent in nitrogen content, it is understandable that no lines lower than the susceptible parent occurred in this population.

The $F_3$ totals for each nitrogen class were fitted to the theoretical normal frequency distribution. Table 4 presents the results. Chi-square was 6.06 and the $P$ value at the 30% point was 6.06. This is a good fit and indicates that nitrogen content exhibits typical quantitative inheritance and is dependent on multiple factors.

TABLE 4.—THEORETICAL NORMAL FREQUENCIES AND ACTUAL FREQUENCIES FOR PER CENT NITROGEN IN THE $F_3$

| Nitrogen class | Theoretical normal frequency | Actual frequency | Nitrogen class | Theoretical normal frequency | Actual frequency |
|---|---|---|---|---|---|
| 2.145 | 2.61 | 2 | 2.645 | 37.70 | 29 |
| 2.245 | 8.14 | 8 | 2.745 | 26.46 | 26 |
| 2.345 | 19.02 | 18 | 2.845 | 13.82 | 11 |
| 2.445 | 31.13 | 36 | 2.945 | 5.38 | 8 |
| 2.545 | 39.98 | 47 | 3.045 | 1.54 | 2 |

### B. *Inheritance of Kernel Weight*

Thousand kernel weight data were obtained on the same 187 $F_3$ lines as were used for nitrogen determinations. The data are presented in the same manner as for nitrogen content.

The distribution of thousand kernel weight for the parents and $F_3$ is given in Table. 5.

Transgressive segregation for kernel weight is indicated by the data presented in Table 5. When the combined distribution for the $F_3$ groups is compared to the combined distribution of the parents, eight (or 4.28%) of the $F_3$ lines fall below the parents and cover a range of four kernel weigh classes. Similarly two (or 1.07%) of the $F_3$ lines exceed the parents, but both lines are in the kernel weight class immediately above the limit of the parents. It is interesting to note that the range of the $F_3$ segregating group falls exactly between the ranges of the resistant and the susceptible groups.

TABLE 5.—FREQUENCY DISTRIBUTION OF THOUSAND KERNEL WEIGHT IN GRAMS FOR THE PARENTS AND DIFFERENT GENOTYPES IN THE $F_3$

| | Thousand kernel weight (1000 KW) in grams | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 19.495 | 20.495 | 21.495 | 22.495 | 23.495 | 24.495 | 25.495 | 26.495 | 27.495 | 28.495 | 29.495 | 30.495 | 31.495 | 32.495 |
| O.A.C. 21 | | | | | | | 1 | 2 | 3 | 6 | 5 | 3 | 1 | |
| Chevron | | | | | 2 | 6 | 8 | 4 | 1 | | | | | |
| Parent totals | | | | | 2 | 6 | 9 | 6 | 4 | 6 | 5 | 3 | 1 | |
| $F_3$ Susc. | | | | | 1 | 2 | 2 | 17 | 15 | 9 | 2 | 4 | 0 | 2 |
| $F_3$ Seg. | | | 1 | 2 | 0 | 10 | 23 | 23 | 21 | 7 | 2 | 1 | | |
| $F_3$ Resis. | 1 | 1 | 1 | 2 | 5 | 10 | 13 | 6 | 4 | | | | | |
| $F_3$ Totals | 1 | 1 | 2 | 4 | 6 | 22 | 38 | 46 | 40 | 16 | 4 | 5 | 0 | 2 |

As indicated above, kernel weight tends to be lower in the progeny than in the parents just as nitrogen content tends to be higher in the progeny than in the parents. This tendency towards low kernel weight can perhaps be explained in the same manner as the tendency toward high nitrogen content. Here again, within the genetic limits of the parents of this cross O.A.C. 21, the susceptible parent, may be nearer to the upper limit for kernel weight than Chevron, the resistant parent, is to the lower limit. Thus, the chances of obtaining a lower kernel weight in relation to the parents, are greater than of obtaining a higher kernel weight.

The $F_3$ totals for each kernel weight class were fitted to the theoretical normal frequency distribution. The results are presented in Table 6. The Chi-square value was 10.74 with the $P$ value between the 10% point (10.64) and the 5% point (12.59). This is again a satisfactory fit. The fit, however, is not as good as for nitrogen. The above result indicates that the inheritance of kernel weight is that of a typical quantitative character and is governed by multiple factors.

TABLE 6.—THEORETICAL NORMAL FREQUENCIES AND ACTUAL FREQUENCIES FOR 1000 K. W. IN THE $F_3$

| 1000 K.W. class | Theoretical normal frequency | Actual frequency | 1000 K.W. class | Theoretical normal frequency | Actual frequency |
|---|---|---|---|---|---|
| 19.495 | .08 | 1 | 26.495 | 39.01 | 46 |
| 20.495 | .33 | 1 | 27.495 | 35.40 | 40 |
| 21.495 | 1.50 | 2 | 28.495 | 18.53 | 16 |
| 22.495 | 4.95 | 4 | 29.495 | 10.27 | 4 |
| 23.495 | 12.55 | 6 | 30.495 | 3.75 | 5 |
| 24.495 | 24.11 | 22 | 31.495 | 1.09 | 0 |
| 25.495 | 35.15 | 38 | 32.495 | .24 | 2 |

### C. *Relationship of the Factors for Nitrogen Content and Kernel Weight to the Factor for Stem Rust Reaction*

This section is concerned with determining as far as possible, whether or not linkage exists between the factor for stem rust reaction and the factors governing nitrogen content and kernel weight. It is not concerned with the effect of stem rust infection on nitrogen content or kernel weight.

Both the simple and partial correlation coefficients are presented in Table 7.

TABLE 7.—SIMPLE AND PARTIAL CORRELATION COEFFICIENTS

| Simple Correlation / Partial correlation | Nitrogen content % | Stem rust reaction | 1000 kernel weight |
|---|---|---|---|
| Nitrogen content % | | −.1697* | −.2065‡ |
| Stem rust reaction | −.0761 | | .5098‡ |
| 1000 kernel weight | −.2855‡ | .6397‡ | |

‡ 1% level of significance attained.
* 5% level of significance attained.

In Table 7 the partial correlation coefficients were calculated with the item not involved held constant. The simple correlation coefficients are in the upper right hand corner and the partial correlation coefficients are in the lower left hand corner. In the following discussion of the correlation coefficients, it should be understood that in the frequency distribution the lowest class represents resistance to stem rust and the highest class susceptibility.

Table 7 reveals that the simple correlation coefficient between nitrogen content and stem rust reaction is negative and quite low. When kernel weight is held constant the partial correlation coefficient remains negative and becomes lower. In other words, as susceptibility to stem rust increases, nitrogen content decreases to a small extent. However, when the effect of kernel weight is removed the amount of decrease in nitrogen content becomes insignificant.

Both the simple and the partial correlation coefficients for kernel weight and stem rust reaction are positive and highly significant. This means that as susceptibility to stem rust increases kernel weight also increases. This is really quite evident on examination of the kernel weight distribution for the $F_3$ population in Table 5.

The simple correlation coefficient between nitrogen content and kernel weight is negative and significant at the 1% point. When the effect of stem rust reaction is held constant the partial correlation remains negative, becomes larger and is still significant at the 1% point. Therefore, as kernel weight increases nitrogen content decreases and vice versa.

In calculating the correlation coefficients numerical values differing by equal amounts were substituted for the stem rust reaction groups (resistant, segregating and susceptible). In view of the fact that the stem rust reaction groups are not actually numerical, combined frequency distributions were tested for independence and association by means of the Chi-square test. This was done to check the reliability of the correlation coefficients for nitrogen content and stem rust, and, kernel weight and stem rust. Following are Tables 8 and 9 used for above tests. Chi-square in both cases was corrected for continuity by the method developed by Yates (13) and described by Goulden (5).

TABLE 8.—COMBINED FREQUENCY TABLE FOR STEM RUST REACTION AND ARBITRARY NITROGEN CLASSES

| Rust class | | Nitrogen content in per cent | | | | | | Totals |
|---|---|---|---|---|---|---|---|---|
| | | 2.20 2.39 | 2.40 2.49 | 2.50 2.59 | 2.60 2.69 | 2.70 2.79 | 2.80 3.09 | |
| Resis. | actual | 4 | 5 | 12 | 12 | 5 | 5 | 43 |
| | theoretical | 6.44 | 8.28 | 10.81 | 6.67 | 5.98 | 4.83 | |
| Seg. | actual | 12 | 18 | 21 | 21 | 13 | 13 | 90 |
| | theoretical | 13.47 | 17.33 | 22.62 | 13.96 | 12.51 | 10.11 | |
| Susc. | actual | 12 | 13 | 14 | 4 | 8 | 3 | 54 |
| | theoretical | 8.09 | 10.39 | 13.59 | 8.37 | 7.51 | 6.06 | |
| Totals | | 28 | 36 | 47 | 29 | 26 | 21 | 187 |

$x^2 = 10.54$ $P = .20(9.80) - .10(12.02)$

TABLE 9.—COMBINED FREQUENCY TABLE FOR STEM RUST REACTION AND ARBITRARY 1000 KERNEL WEIGHT CLASSES

| Rust class | | 1000 Kernel weight | | | | | Total |
|---|---|---|---|---|---|---|---|
| | | 19.00 24.99 | 25.00 25.99 | 26.00 26.99 | 27.00 27.99 | 28.00 32.99 | |
| Resis. | actual | 20 | 13 | 6 | 4 | 0 | 43 |
| | theoretical | 8.28 | 8.74 | 10.50 | 9.20 | 6.21 | |
| Seg. | actual | 13 | 23 | 23 | 21 | 10 | 90 |
| | theoretical | 17.33 | 18.29 | 22.14 | 19.25 | 12.99 | |
| Susc. | actual | 3 | 2 | 17 | 15 | 17 | 54 |
| | theoretical | 10.40 | 10.97 | 13.28 | 11.55 | 7.80 | |
| Totals | | 36 | 38 | 46 | 40 | 27 | 187 |

$x^2 = 50.93$ $P = .01(16.81)$

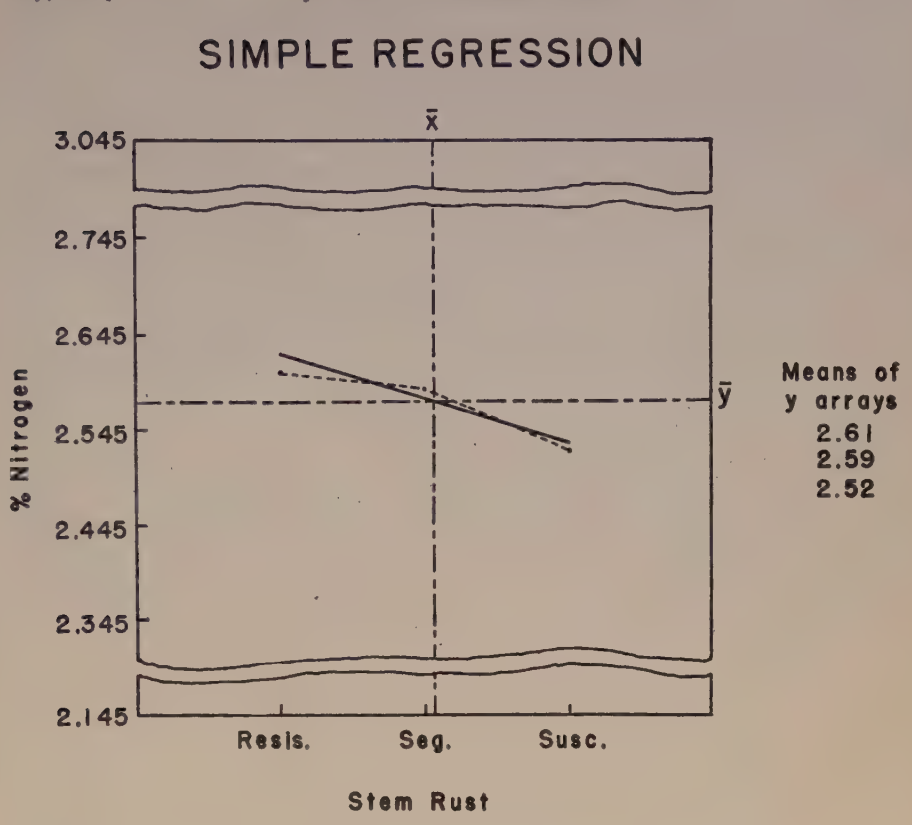


FIGURE 3. Simple regression graph for nitrogen content (%) on stem rust reaction.

In the case of nitrogen content and stem rust reaction there is no evidence of association as shown by Chi-square because in from 10 to 20% of the cases deviations such as obtained would be due to chance. This is the same general conclusion which may be arrived at from the correlation coefficient between these two characters.

With regard to kernel weight and stem rust reaction, there is good agreement between the results obtained by both the test for independence and association and the correlation coefficients. In this case both tests show a strong relationship between these two characters.

It has been shown earlier in this paper that stem rust reaction is governed by a single factor and nitrogen content and kernel weight are governed by multiple factors. We may therefore assume, in view of the above results, that a fairly large percentage of the factors governing kernel weight are linked with the factor for stem rust reaction. We may also assume that very few or none of the factors governing nitrogen content are linked with the factor for stem rust reaction. However, there is a correlation between nitrogen content and kernel weight. This is shown by the significant correlations in Table 7 and by Anderson *et al.* (1). Through this correlation and the association between kernel weight and stem rust reaction, nitrogen is indirectly affected to a small extent by the genotype of a plant for stem rust reaction.

In order to demonstrate graphically the interrelation of the factors for nitrogen content and stem rust, and, the factors for 1000 kernel weight and stem rust, regression lines were plotted. Following are the simple and partial regression coefficients.

| —— | Simple regression coefficient | Partial regression coefficient |
|---|---|---|
| Nitrogen content (%) on stem rust reaction | −.4262* | −.2185 |
| 1000 K.W. (grams) on stem rust reaction | 1.3425‡ | 1.2872‡ |

‡ 1% level of significance attained.
* 5% level of significance attained.

The regression graphs for nitrogen on stem rust are shown in Figures 3 and 4. The simple regression line shows that as recessive genes for stem rust reaction increase, nitrogen content decreases slightly. However, when the effect of kernel weight is removed the regression line becomes almost flat and is insignificant.

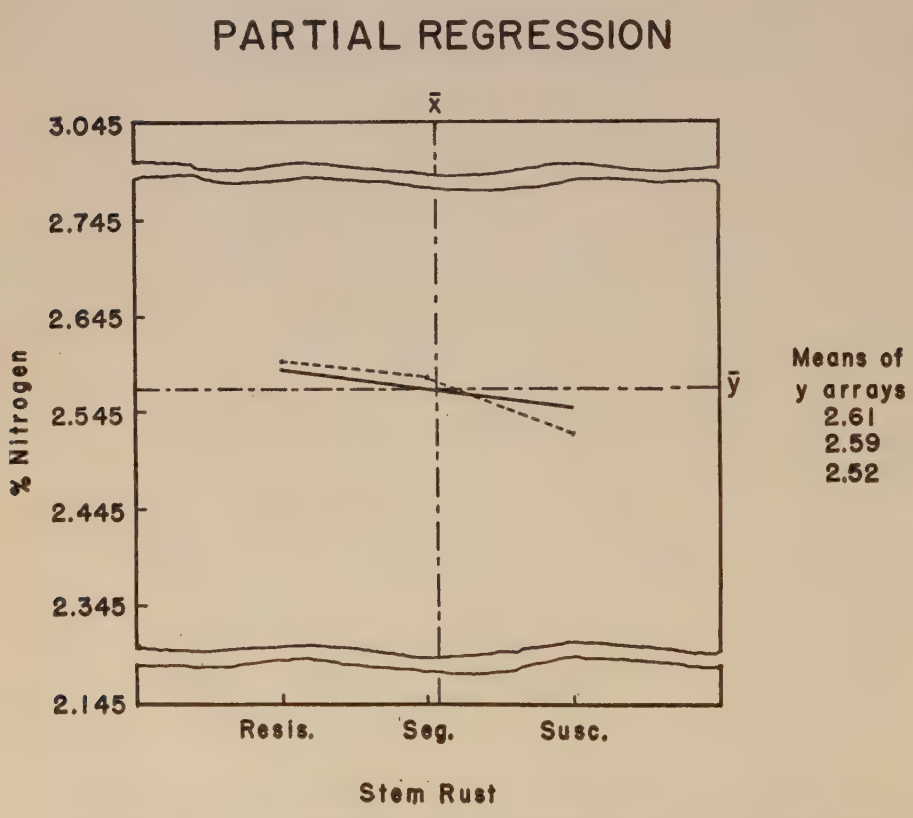


FIGURE 4. Partial regression graph for nitrogen content (%) on stem rust reaction.

The regression graphs for 1000 kernel weight on stem rust reaction are shown in Figures 5 and 6. The simple and partial regression lines are practically identical. In this case as recessive genes for stem rust reaction increase 1000 kernel weight increases. In other words as susceptibility to stem rust increases size of kernal increases. This is the reverse of the combination desirable for good quality rust resistant barley.

The close linkage between kernel weight and stem rust reaction has been broken. A rust resistant $F_3$ selection made (by the author) in 1943 from a bulk lot of the same cross was found to have high kernel weight. The 1000 kernel weight of the selection was 34.46 grams as compared to a weight of 34.16 for a comparable sample of O.A.C. 21.

## SUMMARY AND CONCLUSIONS

In the cross O.A.C. 21 × Chevron, the inheritance of stem rust is governed by a single factor pair with resistance dominant. This factor is probably the same as that found in Peatland by Powers and Hines (8). There is evidence that one or more minor factors modify the reaction of the resistant offspring towards susceptibility. However, the effect of such modifying factors is of no practical significance.

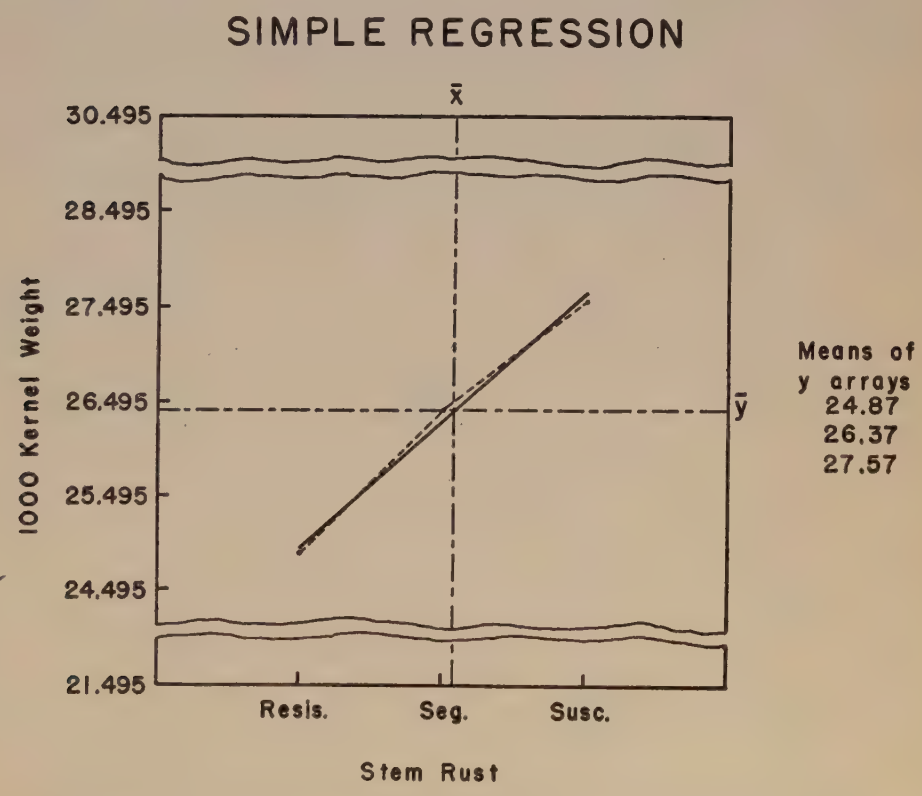


FIGURE 5. Simple regression graph for 1000 kernel weight (grams) on stem rust reaction.

The inheritance of nitrogen content in the same cross is governed by multiple factors. There is a definite tendency for nitrogen content in the $F_3$ progeny to be higher than that of the parents genetically comparable for the stem rust factor.

The inheritance of kernel weight is also governed by multiple factors. In this case, there is a definite tendency towards lower kernel weight in the $F_3$ progeny than in the parents genetically comparable for the stem rust factor.

None or few of the factors for nitrogen content are directly associated or linked with the factor for stem rust reaction. However, some of these factors are apparently associated with it indirectly through its relation to kernel weight. This indirect relationship results in a weak association of high nitrogen content with rust resistance.

A large proportion of the factors for 1000 kernel weight appear to be linked with the factor for stem rust reaction. This linkage is fairly close and results in rust resistance being associated with low kernel weight. However, this linkage was broken when a much larger population was used.

In a breeding program with the objective of producing stem rust resistant barley with good malting quality, using Chevron or possibly Peatland as the source of rust resistance, it would be advisable to grow much larger populations than would be necessary if no linkage existed between kernel weight and the stem rust factor.

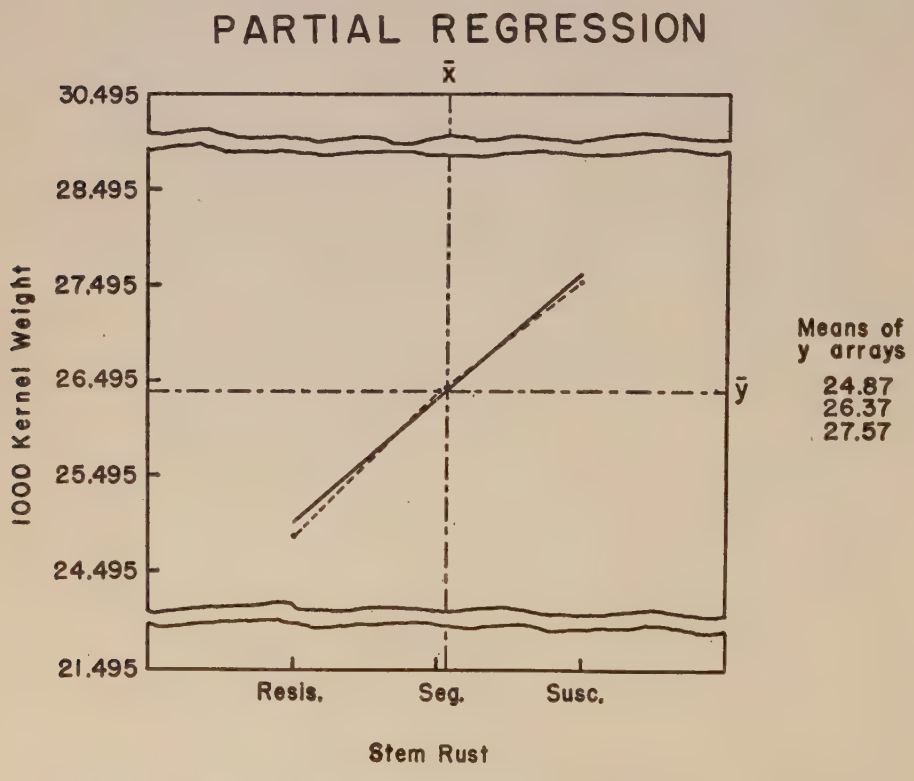


FIGURE 6. Partial regression graph for 1000-kernel weight (grams) on stem rust reaction.

## ACKNOWLEDGMENTS

Grateful acknowledgment is offered for the guidance, assistance and service given during the course of this study by Dr. P. J. Olson, Head of the Division of Plant Science, The University of Manitoba; Dr. R. F. Peterson and Dr. C. H. Goulden of the Dominion Laboratory of Cereal Breeding, Winnipeg; and the staff of the Grain Research Laboratory at Winnipeg.

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# L'IMPORTANCE DES PÂTURAGES NATURELS DANS QUÉBEC[1]

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Le "Relevé écologique des herbages du Québec", projet du Ministère provincial de l'agriculture, fut inauguré en 1940 avec la collaboration de la Station expérimentale fédérale de Ste-Anne de la Pocatière. En 1941, le Collège Macdonald y apportait son concours, après avoir conduit d'autres enquêtes sur les pâturages des Cantons de l'Est. Ce projet de recherches nous a permis d'accumuler de nombreux renseignements sur les gazons naturels[3] du Québec; sur leur nature, leur diversité, leur valeur agronomique et leur répartition géographique.

Dans Québec, comme dans tout pays agricole où l'industrie laitière est à l'honneur, les gazons naturels sont très abondants. La Nature les fait naître spontanément et les propage partout où la forêt fait place à l'agriculture et où la charrue n'a pas, depuis quelques années, bouleversé le sol arable. La Nature accomplit ce travail selon des lois biologiques que nous voudrions mieux connues chez-nous; elle distribue ces gazons d'une façon assez capricieuse et complexe, offrant à notre Province un manteau végétal d'herbages spontanés, aux nuances botaniques des plus diversifiées, où le facteur climat, le sol et l'histoire agronomique des champs se complaisent à exercer une influence souvent complexe.

Les résultats du "Relevé écologique des herbages" nous révèlent à date le partage géographique suivant entre les principales espèces graminoïdes qui poussent spontanément (i.e. sans ensemencement préalable) dans la Province: l'agrostide coloniale (*A. tenuis*) se cantonne plutôt dans le Bas St-Laurent, dans l'Est du Québec, ainsi qu'aux fortes altitudes des Cantons de l'Est; la fétuque rouge traçante (*F. rubra* var. *genuina*), plus généralisée que l'espèce précédente, se partage un vaste domaine qui va, apparemment, de la Gaspésie à St-Hyacinthe et de Huntingdon aux Cantons de l'Est inclusivement, avec au moins des traces importantes dans le district de l'Assomption; l'agrostide commune (*A. alba* L.) se trouve partout dans le Québec, et semble particulièrement abondante dans les Cantons de l'Est, tandis que le pâturin des prés (*P. pratensis* L.) assez répandu dans les comtés de Châteauguay, Huntingdon, Joliette et l'Assomption, devient prédominant dans la région d'Ottawa. Voilà des faits écologiques apparemment dus au facteur climatique.

Quant à l'influence des conditions de sol, soulignons que l'agrostide palustre (*A. palustris* Buds.) abonde dans les habitats frais où le drainage externe est passablement défectueux, tandis que la danthonie à épi (*Dan-*

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[1] Ce travail fut, en substance, présenté au Congrès annuel de l'ACFAS, le 11 Octobre 1943. Il est publié avec l'approbation du Prof. L. C. Raymond.

[2] Assistant, recherches herbagères provinciales.

[3] Au sens écologique du mot, le terme pâturages "naturels" est ici improprement employé. Nous le faisons, toutefois, en accord avec la terminologie du Comité provincial des pâturages et pour éviter la confusion dans la pratique. Au point de vue écologique, nous devrions plutôt dire pâturages semi-naturels, étant donné que nous traitons de la végétation herbacée qui dépend de la Nature et de l'intervention de l'homme. Quant au terme "naturel" il est réservé aux associations végétales qui existent en dehors de l'influence humaine. (Voir A. G. Tansley. The British Islands and their Vegetation, p. 194, Cambridge University Press, 1939, p. 930.)

*thonia spicata*) et les épervières Piloselle et orangée semblent tolérer facilement les sols secs, pauvres et acides. Le pâturin des prés affectionne les endroits exceptionnellement enrichis de fumier animal, ainsi que les terres nouvellement défrichées. Enfin l'agrostide commune, répondant au facteur agronomique, compte parmi les premiers envahisseurs dans les prairies vieillissantes ou dans les jeunes pâturages; et la danthonie semble hériter surtout des terres franches et légères, longtemps soumises à une agriculture abusive.

Les résultats du Relevé écologique, accumulés à date, nous laissent donc apercevoir quelques grands traits de la carte des herbages naturels que nous espérons pouvoir dresser complètement d'ici quelques années[4]. Une telle carte ne semble pas devoir être une expression complète des conditions de notre milieu édapho-climatique, mais, à notre humble avis, elle sera tout de même un bon reflet des conditions dominantes de nos habitats agronomiques. Elle ajoute une note vivante aux grandes lignes cartographiques des sols. C'est vraiment une appréciation partielle de notre milieu. Cette signification écologique n'est pas à dédaigner dans l'organisation de notre future agriculture d'herbages que nous devons, à l'instar des Etats-Unis, organiser chez-nous, agriculture d'herbages dont la vocation multiple en est une d'alimentation animale et de conservation des sols arables. En effet la culture rationnelle des herbages, bien comprise, constitue le meilleur moyen actuellement connu pour conserver économiquement cette ressource naturelle.

Tous les gazons naturels du Québec n'ont pas la même valeur agronomique et, d'une façon générale, leur productivité est inférieure à celle des gazons à court-terme. Ils sont destinés à perdre de leur importance, à l'avenir, selon l'intensification de notre agriculture. Déjà, à cause de leur production médiocre, une antipathie se dessine à leur sujet chez nos cultivateurs progressifs. Il n'en demeure pas moins vrai que leur contribution dans l'alimentation de notre cheptel bovin et ovin restera considérable dans certaines régions où la culture extensive conserve des avantages, ainsi que dans les paroisses de colonisation; ou bien encore dans les districts trop rocheux ou trop montagneux pour être cultivés.

L'importance de nos gazons naturels dépend encore de la possibilité de les améliorer par la fertilisation en surface. Cette possibilité varie avec la nature des gazons, ou des sols qui les déterminent. C'est ainsi que les sols secs, souvent couverts de danthonie ou de mousses (Politrichum), ou encore les sols sensibles à la sécheresse, ne se sont pas montrés favorables à la méthode d'amélioration susmentionnée. Dans ces habitats, la difficulté provient d'un manque d'humidité dans la couche superficielle du sol durant certaines périodes de la saison de végétation et sous certains climats, difficulté qui peut être surmontée à l'aide de plantes douées d'un système radiculaire bien développé en profondeur autant qu'en surface. Ce caractère morphologique est plus ou moins absent chez presque toutes les principales espèces graminoïdes de nos gazons naturels. Cette difficulté peut disparaître temporairement: ce fut le cas des argiles lourdes de la région de St-Hyacinthe durant l'été 1943, où la précipitation atmosphérique, plutôt très abondante, ne fut certainement pas normale.

[4] Ce projet provincial se poursuit depuis le printemps 1944 sous la direction du Prof. L. C. Raymond Collège Macdonald, P. Qué.

Par ailleurs, il y a des cas où les conditions d'humidité sont généralement très favorables durant toute la saison de végétation et où la seule fertilisation en surface ne donne cependant pas des résultats apparemment économiques. Cela dépend de l'état des vieux gazons. Voici deux exemples concrets, pris dans le Bas St-Laurent: l'un dominé par l'agrostide coloniale et l'autre par la fétuque rouge traçante. Dans ces deux cas il y a à la surface du vieux gazon un matelas plus ou moins épais de débris végétaux qui empêche le trèfle blanc sauvage de s'introduire et de se propager facilement. De tels résultats ne sont pas inévitables. Dans le cas de l'agrostide coloniale, le gazon est vieux et formé de touffes serrées les unes contre les autres, touffes que les animaux ne semble pas aimer. Il en résulte que les feuilles seules sont broutées; les gaines et une partie des tiges ainsi délaissées forment des touffes serrées constituant un matelas de débris végétal qui s'épaissit avec les années. Apparemment, en fertilisant adéquatement ces gazons, alors qu'ils sont encore jeunes et avant que le matelas ne se forme, on encouragerait tôt la propagation du trèfle blanc sauvage, et la paissance se ferait alors plus complète. Dans le deuxième cas, celui de la fétuque rouge, plante habituellement beaucoup plus goûtée des animaux, la paissance fut très légère et alors la végétation annuelle séchait et s'accumulait à la surface. Ce gazon, vieux d'une quinzaine d'années, est situé au trait-carré de la ferme. Il représente une exception, mais il sert, tout de même, à démontrer qu'un matelas épais de débris végétaux et accumulé à la surface du sol peut constituer, et constitue très souvent, un obstacle sérieux à l'amélioration économique des gazons naturels par la seule fertilisation en surface. Dans les sols cultivables, il faut détruire, bouleverser ces gazons pour les améliorer rapidement.

La valeur agronomique de nos gazons naturels dans l'agriculture du Quebec dépend aussi de leur utilité et de leur nécessité dans la protection des sols contre l'érosion. Il arrive que les terres ravinées, montagneuses, à pentes trop raides, sont sérieusement exposées à l'érosion si on en détruit la couverture végétale. Sir E. John Russell, directeur de la Station de Rothamsted, Angleterre, disait, dans un congrès scientifique, que l'érosion provient, dans la plupart des cas, d'une destruction de l'équilibre biologique entre le sol et sa couverture végétale. Beaucoup de régions québecoises fournissent des exemples de ces erreurs ou de ces dangers.

L'importance économique de ces gazons naturels est, par ailleurs, diminuée lorsqu'ils entrent en compétition avec un autre gazon, ensemensé celui-là, et plus désirable au point de vue productivité et valeur nutritive, et que l'on voudrait maintenir plus longtemps. Mais ces gazons naturels, mieux adaptés à l'habitat de paissance que ces derniers, et plus agressifs, ont souvent trop vite raison de leurs compétiteurs ensemencés. Cette valeur négative des gazons naturels peut s'accentuer, si les méthodes culturales font défaut dans la préparation adéquate du terrain dans lequel le semis le plus désirable doit être ensemencé; c'est-à-dire, si on a laissé trop de vigueur au gazon spontané. C'est ce qui arrive avec certains vieux gazons naturels (d'agrostide coloniale ou de fétuque rouge) qu'on ne laboure qu'une fois pour les semer en ceréales, avant de les retourner en foin ou en pacage.

## RÉSUMÉ

Si les gazons naturels sont très abondants dans Québec, leur valeur agronomique se mesure à leur productivité, à leurs qualités nutritives; elle varie aussi en fonction de leur "améliorabilité" par la fertilisation appliquée en surface, et de leur utilité contre les menaces de l'érosion. Cependant leur agressivité, en certains cas, est un obstacle à l'amélioration générale de nos herbages.



## SUMMARY

Natural swards are very abundant in Quebec pastures. Their agronomic value depends on their productivity and nutritive value, on their potential improvement by top dressings and their usefulness against soil erosion. They are, however, aggressive, and this is often a drawback in the general betterment of our grasslands, especially with short-term pastures where taller and productive pasture species are concerned.

# THE REACTION OF BARLEY VARIETIES TO WHEAT STEM SAWFLY ATTACK[1]

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The status of barley as a host plant of the wheat stem sawfly (*Cephus cinctus* Nort.) is not well established. Ainslie (1) in his list of host plants states that sawflies attack *Hordeum jubatum* and suggests that cultivated barley "should probably" be added to his host plant list.

Criddle (4, 5, 6, 7) refers to barley as being subject to some sawfly infestation. He points out that this crop is normally seeded late and thus escapes serious injury. There are frequent references to severe initial infestations but no published information on the resulting damage from such attack. In correspondence with headquarters, November 9, 1930, Mr. Criddle discussed barley as follows: "The insect (*Cephus cinctus* Nort.) oviposits freely in common wheat, spring rye, winter rye, durum wheat, emmer, barley and oats. In the first two the sawfly survives and multiplies; in all other grains it finds difficulty in maintaining itself." However, there is no mention of which variety or varieties were under observation but it might be assumed to be Trebi barley, since that variety was commonly grown in Manitoba at that time.

No other published references on the reaction of barley to sawfly damage have been found. The general opinion appeared to be that barley was at least somewhat susceptible to sawfly damage, for as late as 1941 late seeding of barley was recommended in order to avoid sawfly losses (8). Thomson (11) in 1938 and Champlin and Marshall (2) in 1940 published results of experiments in which much higher yields of barley were obtained by early seeding. As a result of publicity given to this work growers rapidly changed over from late seeding of barley to early seeding. If barley were susceptible to sawfly damage this change in seeding practice would result in important economic losses where this insect was prevalent.

Accordingly a series of field observations was begun on sawfly infestation and damage to early-seeded barley, followed by some experiments on varietal differences in reaction to infestation and damage. This paper summarizes the observations made and the experiments conducted, and these are discussed in relation to the sawfly problem.

## FIELD OBSERVATIONS

The sawfly infestation in Apex and Thatcher wheat and Prospect barley under comparable conditions was noted at the Swift Current Station in 1941. All plots were in the late boot and early heading stage of development, which is the ideal stage for maximum oviposition. All stems of both wheat varieties were infested with an average of 4 eggs per stem, while only 3% of the Prospect barley stems were infested with an average of 1 egg per stem. In a second series of replicated, comparable plots of Marquis wheat, Prolific spring rye, Prospect barley and Banner oats, the

[1] A joint contribution of the Division of Entomology, Science Service, and the Cereal Division, Experimental Farms Service, Dominion of Canada Department of Agriculture. Contribution No. 2416 of the Division of Entomology. Contribution No. 137, Cereal Division, Experimental Farms Service.

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rye and wheat were infested 100%, while the oats and barley had infestations of 36 and 40%, respectively. In addition, a number of farmers' fields were examined. In several instances they had seeded strips of Prospect barley on the margins of the wheat fields as traps. In all cases the infestation in the traps was substantially lower than in the wheat crop, this in spite of the fact that the sawflies had to pass through the barley before reaching the wheat and that the stage of development of the barley crop was apparently such that oviposition could readily take place. Sample counts of infestation in the barley and wheat at Blumenhof, Saskatchewan, were 40 and 90% and at Tugaske, Saskatchewan, 25 and 83%, respectively.

At Craigmyle, Alberta, Newal barley was grown in a field severely infested by sawfly. The initial infestation was over 90%, but there was practically 100% larval mortality and no apparent damage in the field.

In 1943 a considerable acreage of Prospect barley was grown in the immediate vicinity of Swift Current, Saskatchewan, in fields severely infested with sawfly. As no wheat was growing in many of these large fields, there was little choice of host plants during the flight period and subsequent initial infestations approached 100%. However, damage to these crops was negligible. Actual counts indicated less than 1% cutting in barley as compared with 80 to 90% in wheat in the same district. Detailed stem examinations revealed that a large proportion of the larvae had died during the period immediately following the hatching of the eggs. Of the few that had fed rather extensively within the stem, less than 5% completed their development and cut the stem.

These observations indicated that while barley might be infested with sawfly to a considerable extent under some conditions, it was highly resistant to sawfly cutting. However, that same fall reports of severe cutting of barley were received from widely scattered points in Saskatchewan and Alberta. Investigations of fields at Rosetown, Plenty and Instow, Saskatchewan, and at Brant, Alberta, revealed that cutting to the extent of approximately 50% had occurred in each case. At Instow the variety grown was O.A.C. 21 and at all the other points it was Hannchen. Collections of the stubble from Brant and Instow for observations on emergence of sawfly adults were made in the spring of 1944. The larvae were active and appeared to be normal in all respects. Subsequent emergence compared favourably with that from wheat. From the Hannchen field at Brant the sexes emerged in approximately equal numbers but from the O.A.C. 21 at Instow there was a preponderance of females.

## VARIETAL TESTS

These field observations strongly suggested that varietal differences as to the degree of sawfly damage existed in barley. Information on such differences might be expected to elucidate the position of barley as a host plant for sawfly and to be of considerable economic significance. Accordingly a small series of varietal tests was conducted, the results of which are presented below.

### Materials and Methods

Nine varieties were chosen for study. These were Hannchen and O.A.C. 21, which appeared to have some susceptibility; Newal and Prospect, which had shown evidence of some resistance; Plush and Rex, recommended

for production in some areas where sawflies were prevalent; Regal and Trebi, varieties formerly grown to a considerable extent in the sawfly area; and Titan, a new variety of considerable promise in this area.

In 1944, test plots were located at Brant, Alberta, and at Swift Current and Shaunavon, Saskatchewan. The nine varieties were grown in single 10-foot rows, replicated three times and arranged as randomized blocks. They were grown on summer-fallow adjacent to infested wheat stubble and the general plan of the tests was similar to that described for wheat (9). At Brant grasshoppers and rodents destroyed the test. At the other two points the percentage of stems infested, the percentage cut and the percentage of larvae parasitized by *Microbracon cephi* Gahan were noted. The percentage of infested stems was arrived at by splitting 20 culms from each plot and noting whether or not they contained eggs or larvae. The presence of either resulted in the stem being classed as infested. To determine the percentage cut, 50 culms were examined in each plot after the crop had matured and the number severed by sawflies noted. It was found that estimates of damage similar to those described for wheat (9) were difficult to make because the barley straw tended to break up after maturity, and only by direct examination could differentiation between sawfly damage and natural breaking be made.

In 1945, tests were located at Nobleford, Alberta, and at Scott, Regina, Shaunavon and Swift Current, Saskatchewan. The same varieties were grown and the general plan of the tests was the same as in 1944 except that 5 replicates were used instead of 3. In addition, 3 nurseries were grown at Swift Current, using 3 dates of seeding, namely, May 1, 10 and 19. The replicates of the three nurseries were randomized over the plot area. The fifth replicate of the late-seeded nursery was discarded because of rodent injury. The percentage infestation was taken on the Nobleford and Swift Current nurseries only and the percentage cutting on all nurseries, both in the same manner as in 1944.

In both years these nurseries were located adjacent to similar nurseries of wheat, and thus it was possible to make a reasonably accurate comparison of the reaction of these two crops to sawfly damage. The design of the nurseries did not allow, however, for a precise statistical comparison.

In analyzing the data from the barley nurseries the following procedure was used. Where data on the percentage of infested stems had been taken, these were transformed to $\mathrm{Sin}^2\ \theta$ and analyzed by variance. The data on percentage of cut stems at Swift Current in 1945 were similarly treated. Those on percentage cut from the other nurseries were transformed to $\sqrt{x + \frac{1}{2}}$ and analyzed in the same manner. These transformations appear to be the most suitable for these data according to the discussion of Cochran (3).

In addition to the above tests the percentage of stems cut by sawflies was noted in each of the varieties grown in the barley yield tests at Swift Current in 1945. These varieties were grown in 3 rod-row plots replicated six times.

## Results

A summary of the data obtained on infestation is presented in Table 1. In Table 2 the varieties are classified for infestation, using Trebi as the

TABLE 1.—PERCENTAGE OF CULMS OF BARLEY VARIETIES INFESTED WITH WHEAT STEM SAWFLY IN VARIOUS NURSERIES, 1944–1945

| Variety | C.A.N. | Percentage infested | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Swift Current | | | | Shaunavon | Nobleford | Averag |
| | | 1944 | 1945* | 1945† | 1945‡ | 1944 | 1945 | |
| Trebi | 753 | 58.3 | 50.0 | 63.3 | 60.0 | 46.6 | 43.6 | 53.6 |
| Plush | 1,117 | 55.0 | 72.0 | 83.3 | 67.5 | 86.6 | 60.6 | 70.8 |
| Prospect | 1,140 | 76.6 | 70.0 | 83.3 | 87.5 | 50.0 | 18.4 | 64.3 |
| Newal | 1,089 | 78.0 | 86.4 | 80.0 | 75.0 | 76.6 | 56.0 | 75.3 |
| Titan | 1,164 | 60.0 | 90.0 | 80.0 | 82.5 | 60.0 | 49.6 | 70.4 |
| O.A.C. 21 | 734 | 65.0 | 86.0 | 96.7 | 100.0 | 60.0 | 42.8 | 75.1 |
| Regal | 742 | 56.6 | 92.0 | 66.7 | 75.0 | 86.6 | 51.0 | 71.3 |
| Rex | 1,113 | 90.0 | 98.0 | 93.3 | 95.0 | 73.3 | 81.4 | 88.5 |
| Hannchen | 837 | 95.0 | 98.0 | 100.0 | 97.5 | 100.0 | 92.8 | 97.2 |
| Average | — | 70.5 | 82.5 | 83.0 | 82.2 | 71.1 | 55.1 | 74.0 |

* Seeded May 1. † Seeded May 10. ‡ Seeded May 19.

TABLE 2.—CLASSIFICATION OF BARLEY VARIETIES BASED ON PERCENTAGE INFESTED, USING TREBI AS THE STANDARD AND THE RESPECTIVE "NECESSARY DIFFERENCES" AS UNITS

| Variety | Swift Current | | | | Shaunavon | Nobleford |
|---|---|---|---|---|---|---|
| | 1944 | 1945* | 1945† | 1945‡ | 1944 | 1945 |
| Plush | 0 | 0 | 0 | 0 | +1 | 0 |
| Prospect | 0 | 0 | 0 | +1 | 0 | +1 |
| Newal | 0 | +1 | 0 | 0 | 0 | 0 |
| Titan | 0 | +2 | 0 | +1 | 0 | 0 |
| O.A.C. 21 | 0 | +1 | +1 | +2 | 0 | 0 |
| Regal | 0 | +2 | 0 | 0 | +1 | 0 |
| Rex | +1 | +2 | +1 | +1 | 0 | +1 |
| Hannchen | +1 | +2 | +1 | +1 | +2 | +2 |

* Seeded May 1. † Seeded May 10. ‡ Seeded May 19.

standard and the necessary differences as units. The necessary differences were calculated by multiplying the standard errors of the mean difference by the value of $t$ at the 5% point. The means, standard errors, $F$ values, etc., are given in Table 3. Significant varietal differences were obtained in all tests. Trebi was the most resistant to infestation, Hannchen and Rex the most susceptible. The differences among the other varieties were not great.

Table 4 is a summary of the data on cutting by sawfly, and in Table 5 the varieties are classified for cutting, using Trebi as the standard and the necessary differences as units. Significant varietal differences were established in all tests but one. On the average, Trebi had the least cutting and in no individual test did any variety have significantly less. Hannchen suffered the greatest damage, having significantly more cutting than Trebi in all tests. Rex also showed considerable susceptibility. Plush, Prospect,

TABLE 3.—MEANS, STANDARD ERRORS, ETC., OF DATA ON PERCENTAGE INFESTATION AND CUTTING OF BARLEY VARIETIES EXPOSED TO SAWFLY ATTACK (DATA TRANSFORMED FROM PERCENTAGES TO $\sin^2\theta$ OR $\sqrt{x+\frac{1}{2}}$ AS SHOWN)

| Station | Year | Mean | S.E. | S.E. in per cent | N.D. | F | 5 per cent point | Transformation used |
|---|---|---|---|---|---|---|---|---|
| *Percentage Infested* | | | | | | | | |
| Swift Current | 1944 | 58.7 | 4.97 | 8.5 | 14.9 | 5.00 | 2.59 | $\sin^2\theta$ |
| | 1945* | 70.8 | 5.40 | 7.6 | 15.0 | 7.18 | 2.25 | $\sin^2\theta$ |
| | 1945† | 69.6 | 6.20 | 8.9 | 18.6 | 3.88 | 2.59 | $\sin^2\theta$ |
| | 1945‡ | 69.5 | 6.13 | 8.8 | 17.9 | 4.96 | 2.36 | $\sin^2\theta$ |
| Shaunavon | 1944 | 61.2 | 7.58 | 12.4 | 22.7 | 3.76 | 2.59 | $\sin^2\theta$ |
| Nobleford | 1945 | 48.5 | 5.05 | 10.4 | 14.0 | 9.42 | 2.25 | $\sin^2\theta$ |
| *Percentage Cut* | | | | | | | | |
| Swift Current | 1944 | 2.64 | 0.50 | 18.9 | 1.50 | 1.85 | 2.59 | $\sqrt{x+\frac{1}{2}}$ |
| | 1945* | 30.5 | 3.23 | 10.6 | 9.00 | 10.80 | 2.25 | $\sin^2\theta$ |
| | 1945† | 24.7 | 4.55 | 18.4 | 12.6 | 3.22 | 2.25 | $\sin^2\theta$ |
| | 1945‡ | 21.3 | 4.25 | 20.0 | 12.4 | 5.07 | 2.36 | $\sin^2\theta$ |
| Shaunavon | 1944 | 1.08 | 0.29 | 26.8 | 0.87 | 6.60 | 2.59 | $\sqrt{x+\frac{1}{2}}$ |
| | 1945 | 1.24 | 0.37 | 29.8 | 1.02 | 2.63 | 2.25 | $\sqrt{x+\frac{1}{2}}$ |
| Nobleford | 1945 | 1.49 | 0.39 | 26.2 | 1.08 | 2.97 | 2.25 | $\sqrt{x+\frac{1}{2}}$ |
| Regina | 1945 | 1.91 | 0.32 | 16.8 | 0.89 | 19.79 | 2.25 | $\sqrt{x+\frac{1}{2}}$ |
| Scott | 1945 | 1.31 | 0.29 | 22.1 | 0.80 | 5.69 | 2.25 | |

* Seeded May 1. † Seeded May 10. ‡ Seeded May 19.

and Newal were quite resistant. The damage to Titan, on the average, was slightly greater than in Newal, but it was significantly higher than in Trebi in three tests whereas in Newal it was significantly higher in only one. It will be noted that the varieties tended to fall in the same order for both infestation and cutting.

A summary of the data on the parasitism sustained by the sawflies in the various varieties is presented in Table 6. In general, those varieties having the heaviest infestations had the greater percentage of the sawflies parasitized. It might be expected that the parasites would tend to concentrate where hosts were most numerous (10).

Data on the percentage cutting sustained by a few of the varieties in the rod-row test at Swift Current in 1945 are presented in Table 7. Average results on cutting from the seven nurseries are also presented. These data, though admittedly meagre, suggest that there are varieties which might be much more susceptible than any that were included in the nurseries.

Based on the average of all varieties in the dates-of-seeding tests at Swift Current in 1945, the three dates of seeding showed no appreciable difference in infestation (Table 1). Similar data for cutting show a lessening

TABLE 4.—PERCENTAGE OF CULMS OF BARLEY VARIETIES CUT BY WHEAT STEM SAWFLY IN VARIOUS NURSERIES, 1944–1945

| Variety | Percentage cut | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Swift Current | | | | Shaunavon | | Noble-ford | Regina | Scott | Average |
| | 1944 | 1945* | 1945† | 1945‡ | 1944 | 1945 | 1945 | 1945 | 1945 | |
| Trebi | 5.0 | 8.8 | 4.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 |
| Plush | 1.7 | 16.8 | 15.2 | 5.0 | 0.0 | 0.0 | 2.2 | 0.8 | 0.8 | 4.7 |
| Prospect | 5.0 | 15.2 | 17.6 | 6.0 | 0.0 | 0.0 | 0.8 | 0.8 | 4.0 | 5.5 |
| Newal | 6.7 | 27.2 | 10.4 | 7.0 | 0.0 | 0.8 | 1.4 | 1.6 | 0.0 | 6.1 |
| Titan | 8.3 | 19.2 | 13.6 | 12.0 | 0.0 | 0.8 | 1.4 | 4.8 | 0.8 | 6.8 |
| O.A.C. 21 | 10.0 | 23.2 | 24.8 | 20.0 | 1.7 | 3.2 | 1.6 | 0.0 | 0.0 | 9.4 |
| Regal | 8.3 | 38.4 | 15.2 | 29.0 | 0.0 | 1.6 | 3.0 | 5.6 | 1.6 | 11.4 |
| Rex | 6.7 | 48.0 | 36.0 | 26.0 | 1.7 | 3.2 | 6.0 | 8.8 | 4.8 | 15.7 |
| Hannchen | 15.0 | 53.6 | 40.8 | 31.0 | 8.3 | 6.8 | 8.2 | 25.6 | 6.4 | 21.7 |
| Average | 7.4 | 27.8 | 19.7 | 15.2 | 1.3 | 1.8 | 2.7 | 5.3 | 2.0 | 9.3 |

* Seeded May 1. † Seeded May 10. ‡ Seeded May 19.

TABLE 5.—CLASSIFICATION OF VARIETIES BASED ON PERCENTAGE CUT USING TREBI AS THE STANDARD AND THE "NECESSARY DIFFERENCES" AS UNITS

| Variety | Swift Current | | | Shaunavon | | Noble-ford | Regina | Scott |
|---|---|---|---|---|---|---|---|---|
| | 1945* | 1945† | 1943‡ | 1944 | 1945 | 1945 | 1945 | 1945 |
| Plush | +1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Prospect | 0 | +1 | 0 | 0 | 0 | 0 | 0 | +1 |
| Newal | +1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Titan | +1 | 0 | +1 | 0 | 0 | 0 | +1 | 0 |
| O.A.C. 21 | +1 | +1 | +1 | 0 | +1 | 0 | 0 | 0 |
| Regal | +2 | 0 | +2 | 0 | 0 | 0 | +1 | 0 |
| Rex | +3 | +1 | +1 | 0 | 0 | +1 | +2 | +1 |
| Hannchen | +3 | +2 | +2 | +2 | +1 | +1 | +4 | +2 |

* Seeded May 1. † Seeded May 10. ‡ Seeded May 19.

of damage as seeding was delayed (Table 4). However, owing to low spring temperatures that delayed development of the early-seeded grain and to an abnormally long sawfly flight period, no conclusions should be drawn from this experiment.

The infestation of susceptible wheat varieties in nurseries adjacent to the barley tests was, in all cases, in excess of 90%. Among the barleys only Hannchen equalled this figure but Rex approached it closely. The percentage cutting in Apex and Thatcher wheat was 80 and 75, respectively, whereas comparable figures for Rex and Hannchen were 16 and 22. Thus, in these tests wheat was much more susceptible than barley. The percentage of sawfly larvae parasitized in barley varieties varied from 6 to 51% (Table 6). In the adjacent wheat nurseries the percentage parasitism was less than 5% except in the case of one very late-maturing variety. No

TABLE 6.—PERCENTAGE OF WHEAT STEM SAWFLY LARVAE IN BARLEY VARIETIES PARASITIZED BY *Microbracon cephi* AT SWIFT CURRENT AND SHAUNAVON, SASKATCHEWAN, 1944

| Variety | Percentage parasitized | | |
|---|---|---|---|
| | Swift Current | Shaunavon | Average |
| Trebi | 0 | 13 | 6 |
| Plush | 33 | 13 | 23 |
| Prospect | 14 | 12 | 13 |
| Newal | 28 | 10 | 19 |
| Titan | 8 | 18 | 13 |
| O.A.C. 21 | 26 | 20 | 23 |
| Regal | 17 | 18 | 18 |
| Rex | 49 | 35 | 42 |
| Hannchen | 51 | 52 | 51 |

TABLE 7.—COMPARATIVE DAMAGE TO BARLEY VARIETIES BY WHEAT STEM SAWFLY IN NURSERIES AND VARIETAL TEST PLOTS AT SWIFT CURRENT

| Variety | C.A.N. | Percentage cut | |
|---|---|---|---|
| | | Average of 7 nurseries | Rod-row test |
| Trebi | 753 | 2.1 | 0.0 |
| Plush | 1,117 | 4.7 | 0.0 |
| Prospect | 1,140 | 5.5 | 0.0 |
| Newal | 1,089 | 6.1 | 0.0 |
| Titan | 1,164 | 6.8 | 0.0 |
| O.A.C. 21 | 734 | 9.4 | 0.0 |
| Regal | 742 | 11.4 | 0.0 |
| Rex | 1,113 | 15.7 | 1.0 |
| Hannchen | 837 | 21.7 | — |
| Compana | 1,154 | — | 2.5 |
| Glacier | 1,149 | — | 6.6 |
| Beecher | 1,153 | — | 9.3 |
| Atlas | 702 | — | 14.1 |
| Bulk sel. C. I. 7008 | — | — | 15.8 |

explanation suggests itself as to why the parasites should concentrate in the barley when larger numbers of potential hosts were available in the wheats.

An examination of Table 4 reveals that the damage sustained by the barleys varied greatly from nursery to nursery. This would suggest that environmental factors markedly influence the degree of damage. The data are too meagre to attempt to postulate what these environmental factors might be and what effect they might have.

## DISCUSSION

The results of the varietal tests show that differences in reaction to sawflies exist among barleys. These differences were, very largely, in agreement with previous field observations. Thus Newal and Prospect were observed to suffer little damage in the field and in the tests proved to be

quite resistant. Similarly, in all but one of the fields showing severe damage the variety was Hannchen, and in the tests it showed susceptibility. The one exception was the severely damaged field of O.A.C. 21 at Instow. In the nurseries O.A.C. 21 was not particularly susceptible. Apparently conditions were abnormally favourable for sawfly damage in that particular field.

It would appear that certain varieties of barley, notably Hannchen, serve as hosts for sawfly. However, even in Hannchen the small amount of cutting sustained in all nurseries except those at Swift Current suggests that the insect would have difficulty in maintaining itself on this variety alone. Further information is needed on the emergence of adults and their fecundity before the suitability of this variety as a host plant can be completely assessed. There is no doubt, however, that the sawflies from Hannchen stubble would constitute a serious menace to adjacent wheat. Furthermore, there may be some varieties of barley more susceptible than Hannchen, as indicated from the data presented in Table 7. In most instances the damage in the nurseries was not as great as that found in the field. Hence it may be possible that under different environmental conditions greater damage may occur. However, there is no evidence to suggest that any barley is likely to suffer damage to the same extent as Apex, Marquis or Thatcher wheat.

The greatest menace from sawflies in barley is not so much the loss to the barley crop as the potential menace to adjacent wheat from sawflies emerging from barley stubble. Barley is widely used to clean up severely infested areas, which are then returned to wheat production. Observations indicate that only rarely has wheat sown under such circumstances suffered damage. This is probably because the barleys grown in the sawfly area are almost entirely Trebi, Newal, Plush and Prospect. These varieties are quite resistant according to the results of the present investigation. This happy state of affairs occurred by chance but may not be maintained unless precautions are taken. Many new varieties and hybrid lines have been produced that show promise, agronomically, in the sawfly area. It is entirely possible that some of these, at least, are susceptible to sawfly damage. It appears desirable to determine the sawfly reactions of such varieties before they are recommended for commercial production. There is apparently a wealth of material that has resistance, and therefore it should be relatively easy to maintain this in any new varieties that are produced for this area.

## SUMMARY

In recent years growers on the open plains of western Canada have been seeding barley early, whereas formerly the practice had been to sow late. By seeding early they exposed the crop to attack by the wheat stem sawfly (*Cephus cinctus* Nort.). Field observations showed that practically no damage was sustained by the varieties Prospect and Newal, when seeded early. Investigations of reports of severe damage to barley showed that in all cases, except one, Hannchen was the variety grown, thus indicating that varietal differences existed.

Nine varieties were seeded in replicated, single-row plots in various locations in 1944 and 1945. Significant varietal differences in infestation were established in all nurseries and in cutting in all but one nursery.

These results were in general agreement with previous field observations. From the standpoint of both infestation and cutting there was a tendency for the varieties to fall in the same order. Trebi was the most resistant; Plush, Prospect and Newal were almost equally so; while Hannchen and Rex were the most susceptible to damage. None of the barleys sustained damage to the same extent as adjacent plots of Apex, Marquis or Thatcher wheat. Parasitism of sawflies in barley, by *Microbracon cephi* Gahan, was much greater than in wheat. The amount of damage to the barley varieties varied greatly from station to station, indicating that environmental factors influence the degree of damage.

It is pointed out that even though the economic damage to susceptible barleys is relatively small, such fields provide reservoirs of infestation that are a menace to nearby wheat. At present the barley acreage in the sawfly area is now seeded almost exclusively to sawfly resistant varieties. It is suggested that the introduction of susceptible varieties be avoided.

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# PRELIMINARY OBSERVATIONS ON SOME EFFECTS OF ARTIFICIAL DEFOLIATION OF WHEAT PLANTS[1]

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Grasshoppers are among the most widespread and persistent pests of cereals that occur on the Canadian prairies. Even though they can be controlled, they frequently damage plants and cause serious losses that may be overlooked. It is quite a common occurrence for newly hatched 'hoppers to devour all the leaves of young wheat plants, leaving the field apparently quite bare. Older 'hoppers and adults will frequently strip he leaves from well develope d plants, leaving only a bare stem with the head intact.

If the grasshoppers are destroyed, the plants will sometimes appear to recover, put out new leaves and develop fairly normally. At such times the question arises as to what effect this leaf removal has actually had on the ultimate yield or quality of the grain. The answers to this question by cerealists and agronomists have been so contradictory that a small-scale experiment was started in 1936 to secure some definite information. The results were so marked that the experiment was repeated in 1937 on a larger scale. In both of these experiments there were errors in planning which could not be foreseen and which seriously affected the results. These faults were corrected in 1938 and the experiment conducted for a third time.

The results of the 1938 experiment agreed in the chief essentials with the experiments of the two previous years. The crop suffered the most damage by defoliation when it was heading out and blooming but appeared to benefit by this operation when it was ripening.

## METHODS

Fifteen plots of wheat, each consisting of 14 rod-rows, were seeded with a Kemp hand drill on April 25. The rows were spaced 1 foot apart, and 200 kernels of registered Marquis wheat were seeded in each row. The plots were arranged in 5 rows of 3 plots each, with a space of 4 feet between the rows of plots and a space of 1 foot between the plots in each row. Wheat was sown with a drill around the four sides of the block of plots to offset marginal effect.

An effort was made to simulate grasshopper damage in 12 of the 15 plots, the other 3 being left as checks. The checks were located as follows:—No. 3, the right-hand plot in the first row; No. 8, the centre plot in the third row; and No. 13, the left-hand plot in the fifth row. Thus the check plots were placed diagonally across the block of plots. When No. 15 was about to be clipped it was found that practically all of the leaves were dried up and it appeared as if defoliation would have no effect. For this reason only half of the plot was defoliated, the other half, No. 15*b*, being used as an additional check.

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In plots Nos. 1 and 2 the plants were cut off at the ground level. In the remaining plots the leaves were removed, leaving the main stem intact, as has frequently been observed where grasshoppers have been abundant. Each plot received the one defoliation only and was left untouched for the remainder of the season, as would happen if an invasion had been controlled at that time and there had been no further infestation.

The first plot was cut on May 10 when the plants were $\frac{1}{2}$ to $1\frac{1}{2}$ inches high. The leaves were cut from the plants in the remaining 11 plots in successive weeks.

When the plants came through the ground it was evident that there were not 200 in each row, so an attempt was made to count them. By the time the last plots were counted considerable stooling had taken place and it was found to be impossible to make an accurate check. This was compensated for to some extent by recording the number of heads at the time the plots were harvested.

Soil moisture samples were taken in each plot in May, June and July, but as there was a mean variation of only 1.1% between the wettest and driest plots, the moisture content was disregarded in analyzing the results of the experiment.

As the crop in each plot ripened, the 10 centre rows were harvested by hand, the two outside rows having been seeded to offset marginal effect. The grain was threshed in a rod-row thresher, and while some kernels were lost in the threshing, this loss was probably proportionally the same for each plot, so it was disregarded.

## RESULTS

Table 1 and Figure 1 contain the data obtained from this project; these data may be summarized as follows.

### *Yield*

The mean of the check plots was 48.6 bushels per acre. The first three plots defoliated suffered a loss of 12.6 to 16.8%, the next four 4.3 to 9.6%, the next three 20.3 to 29.1%, the second last 0.5%, and the last plot showed a *gain* of 2.9%. The three plots which suffered most severely were defoliated during the period of heading-out to just after blooming.

### *Grade*

The grain from all plots was No. 1 Hard in milling quality, but that from 14 plots lacked the required weight to qualify for this grade. The other plot was defoliated on June 20, a week before the grain headed out. Ten of the plots graded No. 1 N., and four, including one of the check plots, graded No. 2 N.

### *Days Required to Mature*

The defoliated plots required 1.9 days longer to mature than the mean of the check plots. The first plot clipped matured 1 day earlier than any of the checks. All of the other defoliated plots were 5 to 7 days longer in maturing than No. 1 plot.

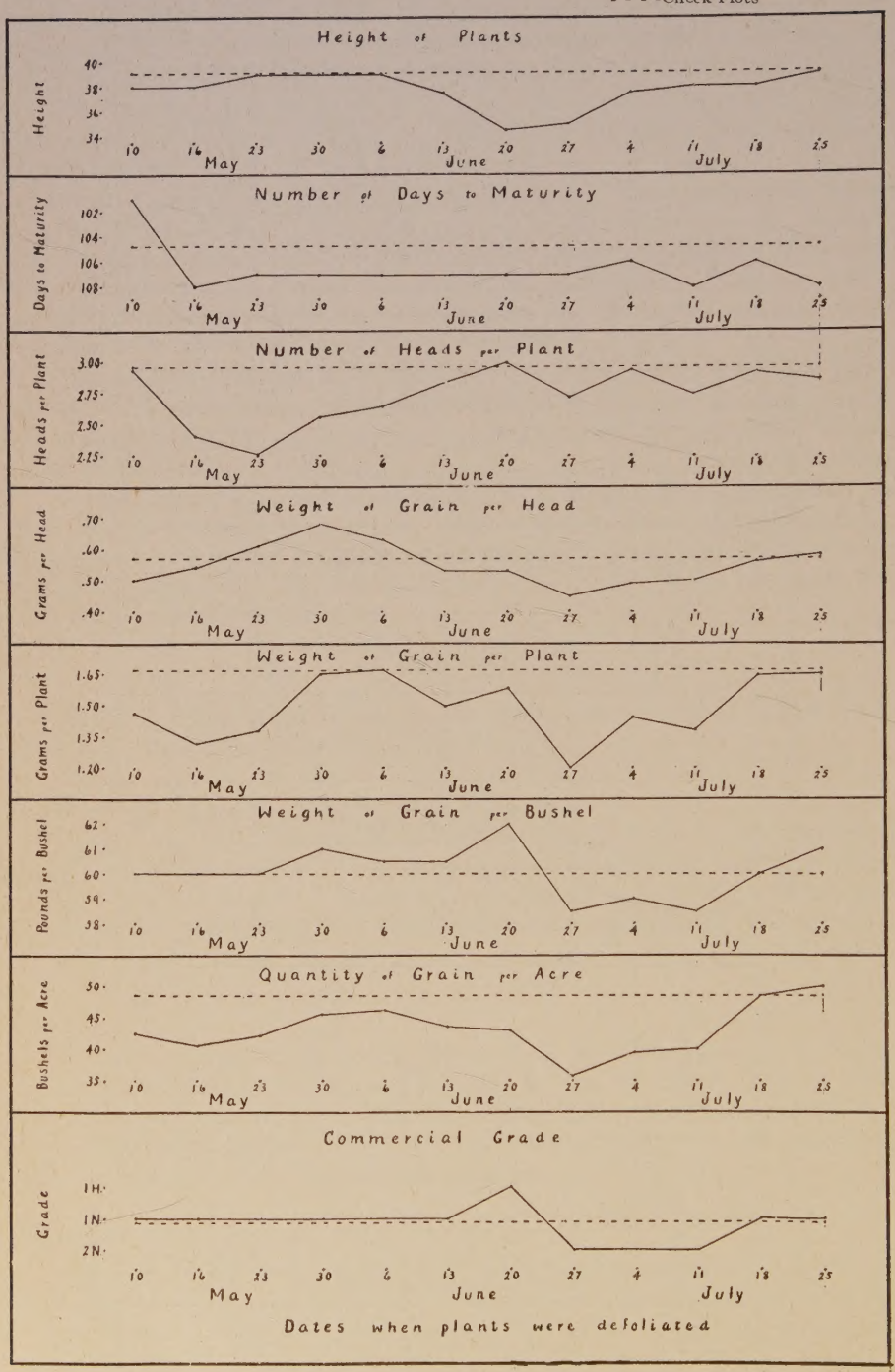
TABLE 1.—EFFECT ON CROP OF DEFOLIATION OF WHEAT

| Plot No. | Date clipped | No. days from seeding | Stage of wheat | Height of ripe wheat | Number of | | | Weight of grain per | | | | Bushels per acre | Pounds per acre | Grade | Mean soil moisture | No. days to cutting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Plants | Heads | Heads per plant | Plot | Plant | Head | Bushel | | | | | |
| | | | | (inches) | | | | (grams) | (grams) | (grams) | (pounds) | | | | | |
| 1 | May 10 | 15 | ½ – 1½ inches | 38.0 | 1,743 | 5,102 | 2.93 | 2,548 | 1.46 | .50 | 60.0 | 42.5 | 2,550 | 1 N | 13.3 | 101.0 |
| 2 | May 16 | 22 | 2½ inches (1–5 leaf) | 38.0 | 1,860 | 4,473 | 2.40 | 2,428 | 1.31 | .54 | 60.0 | 40.5 | 2,430 | 1 N | 13.3 | 108.0 |
| 4 | May 23 | 29 | 3 inches | 39.0 | 1,833 | 4,136 | 2.26 | 2,529 | 1.38 | .61 | 60.0 | 42.1 | 2,526 | 1 N | 14.0 | 107.0 |
| 5 | May 30 | 36 | 4 inches | 39.0 | 1,655 | 4,031 | 2.56 | 2,735 | 1.65 | .68 | 61.0 | 45.6 | 2,782 | 1 N | 14.0 | 107.0 |
| 6 | June 6 | 43 | 6 inches | 39.0 | 1,663 | 4,390 | 2.64 | 2,772 | 1.67 | .63 | 60.5 | 46.2 | 2,795 | 1 N | 14.2 | 107.0 |
| 7 | June 13 | 50 | — | 37.5 | 1,756 | 4,964 | 2.83 | 2,617 | 1.49 | .53 | 60.5 | 43.6 | 2,638 | 1 N | 14.0 | 107.0 |
| 9 | June 20 | 57 | — | 34.5 | 1,628 | 4,882 | 2.99 | 2,581 | 1.58 | .53 | 62.0 | 43.0 | 2,666 | 1 H | 14.3 | 107.0 |
| 10 | June 27 | 64 | Heading | 35.0 | 1,748 | 4,761 | 2.72 | 2,145 | 1.20 | .45 | 58.5 | 35.7 | 2,088 | 2 N | 13.6 | 107.0 |
| 11 | July 4 | 71 | Blooming | 37.5 | 1,641 | 4,812 | 2.93 | 2,360 | 1.44 | .49 | 59.0 | 39.3 | 2,318 | 2 N | 13.8 | 106.0 |
| 12 | July 11 | 78 | — | 38.0 | 1,742 | 4,774 | 2.74 | 2,399 | 1.38 | .50 | 58.5 | 40.0 | 2,340 | 2 N | 14.1 | 108.0 |
| 14 | July 18 | 85 | — | 38.0 | 1,774 | 5,180 | 2.92 | 2,902 | 1.64 | .56 | 60.0 | 48.4 | 2,904 | 1 N | 13.5 | 106.0 |
| *15a | July 25 | 92 | Wheat ripening, leaves all brown | 39.0 | 909 | 2,598 | 2.86 | 1,499 | 1.65 | .58 | 61.0 | 50.0 | 3,005 | 1 N | 13.5 | 108.0 |
| | Mean | | | 37.7 | 1,735 | 4,705 | 2.73 | 2,567 | 1.48 | .55 | 60.1 | 43.1 | 2,587 | 1 N | — | 106.6 |
| 3 | Check | | | 39.0 | 1,785 | 4,988 | 2.79 | 2,943 | 1.65 | .59 | 61.0 | 49.0 | 2,989 | 1 N | 13.6 | 102.0 |
| 8 | Check | | | 40.0 | 1,629 | 5,048 | 3.09 | 2,931 | 1.80 | .58 | 60.0 | 48.9 | 2,934 | 1 N | 14.3 | 103.0 |
| 13 | Check | | | 38.5 | 1,792 | 5,360 | 2.99 | 2,825 | 1.58 | .53 | 59.0 | 47.1 | 2,779 | 2 N | 13.2 | 106.0 |
| *15b | Check | | | 39.0 | 889 | 2,630 | 2.96 | 1,489 | 1.67 | .57 | 60.5 | 49.6 | 2,976 | 1 N | 13.5 | 108.0 |
| | Mean | | | 39.1 | 1,742 | 5,150 | 2.96 | 2,911 | 1.67 | .57 | 60.0 | 48.6 | 2,919 | 1 N | — | 104.7 |

* Five rows only.

Figure No. 1

SOME EFFECTS OF ARTIFICIAL DEFOLIATION



*Height of Plants*

The plants in the defoliated plots were all slightly shorter than those of the mean of the checks, while in two plots they were 4 to 4½ inches shorter. One of these latter plots was clipped when the wheat was heading out and the other during the previous week.

*Number of Heads per Plant*

There was a serious reduction in the number of heads per plant in the plots defoliated in the second to the fifth weeks, inclusive, but in the other plots the reduction was not conspicuous.

*Weight of Grain per Plant*

Only No. 6 plot, defoliated on June 6, produced as much grain per plant as the mean of the check plots. The plants in the first three plots and in the eighth to the tenth all suffered quite severely. The last two plots of the series were not materially affected.

In summarizing the results of the experiment one is forced to the conclusion that defoliation of the wheat plant is detrimental at any stage in its development except during the last two weeks before the grain is ripe, at which time the operation appears to be beneficial.

## SUMMARY

1. Defoliation of the wheat plant, at any stage in its development, did not necessarily result in crop failure.

2. The yield suffered most when the plant was defoliated during the heading to dough stages.

3. Defoliation of the plant during the two weeks previous to its maturity was not injurious to the plant, as indicated by the yield.

4. Defoliation of the growing plant did not affect the quality of the grain but did affect the quantity and also the weight of grain per bushel.

## ACKNOWLEDGMENTS

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## BOOK REVIEW

CANADIAN AGRICULTURAL POLICY—THE HISTORICAL PATTERN, by Veron C. Fowke, The University of Toronto Press, 304 pages, 1946. $3.50.

Farmers to-day are actively interested in agricultural policy. With the painful experiences of Post-World War I, and the depression years of the 1930's still distinct, they are anxious to consolidate their gains and attain a stability that may come out of a price support program. That the farmers can attain this by sheer pressure weight of political influences is not necessarily true. Professor Fowke's study leads him to believe that: "There is little justification for the general impression that down through the generations the embattled Canadian farmer has won grudging concessions from the entrenched interests of commerce, finance, and industry, either by the pressure of endless complaint or by an appeal to reason and justice. The Canadian farmer has had political power, but this power has varied in proportion to the contribution which agriculture could make, at any given time, to the cause of commerce, finance, and industry, rather than in proportion to farmers' numbers or their state of organization."

This book is timely and fills an important need by providing a historical perspective of Canadian agricultural policy. The book is not only useful to those who actively make policy but to those who teach it.

Professor Fowke divided his book into two parts, the first entitled the Pre-Confederation Period, and the second part Federal Agricultural Policy. In the second part he reviews the division of powers between the federal and provincial governments at Confederation, the encouragement of immigration and settlement, the livestock and dairy industries, and the production and marketing of wheat.

Professor Fowke concludes that: "As for providing investment opportunities, the frontier role, Canadian agriculture excelled in this capacity from 1900 to 1930 during the opening up of wheat production in the Canadian West..... The vital frontier of Canadian investment in fixed equipment since 1930 has been in the Precambrian Shield instead of in the Agricultural West, in newsprint and minerals instead of in wheat. These facts call for a new Canadian philosophy not only of agricultural functions and agricultural policy, but also of the relationship between the federal and provincial governments in regard to agriculture."

—FRANK SHEFRIN.